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1981 CRC ALTITUDE OCTANE REQUIREMENT PROGRAM

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1981 CRC ALTITUDE OCTANE REQUIREMENT PROGRAM

(CRC PROJECT NO. CM-124-81)

Prepared by the

1981 Altitude Octane Requirement Program
Analysis Panel

of the

CRC Road Test Group

December 1981

Light-Duty Vehicle Fuel, Lubricant,
and Equipment Research Committee

of the

Coordinating Research Council, Inc.

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I. SUMMARY

The last CRC altitude octane program was run in 1977. Since then, vehicle designs have changed substantially. In particular, many of the 1981 models are equipped with electronic systems for controlling air-fuel mixture and spark timing. Consequently, this program was run to determine the effect of altitude on octane requirements of 1981 cars with electronic control systems and to provide data for ASTM to consider for possible revision of the D 439 altitude octane specifications for gasoline. The results from this program are summarized as follows:

- Octane requirement tests were conducted in Denver, Colorado, at an elevation of 5,280 feet above sea level; and again in Los Angeles, California, at an elevation of 325 feet. Seventy-six cars were tested at each location. There were seven groups of ten cars each; two groups had barometrically compensated spark timing, and five did not. Six other cars also had barometric spark compensation, and three of those cars had knock sensors. All cars had closed-loop electronic control of air-fuel mixtures. Maximum octane requirements were determined with unleaded average sensitivity full-boiling range (FBRU) reference fuels and with unleaded high sensitivity full-boiling range (FBRSU) reference fuels. In addition, 50th percentile acceleration technique octane requirements were determined with FBRU fuels.

- The average octane requirements (raw and temperature-humidity corrected data) are summarized as follows:

		Octane Req. (RON)** Los Angeles		Denver		Difference (RON)		ΔONR/1000 ft. (RON)	
		Raw	Corr.	Raw	Corr.	Raw	Corr.	Raw	Corr.
50 Cars without Spark Timing Compensation	FBRU Max.	91.6	91.2	83.4	83.9	8.2	7.3	1.7	1.5
	FBRU 50%*	91.5	91.1	82.8	83.2	8.7	7.9	1.8	1.6
	FBRSU Max.	92.7	92.3	84.8	85.2	7.9	7.1	1.6	1.4
20 Cars with Spark Timing Compensation	FBRU Max.	92.4	92.0	89.2	89.5	3.2	2.5	0.6	0.5
	FBRU 50%*	91.4	91.0	88.8	89.0	2.6	2.0	0.5	0.4
	FBRSU Max.	93.8	93.4	90.6	90.8	3.2	2.6	0.6	0.5

- For the cars with knock sensors in addition to spark compensation, the reductions in octane requirements with increasing altitude were similar to those shown above for the twenty cars with spark compensation alone.

- With FBRU fuels, the reduction in maximum octane requirements (raw data) per 1,000 feet increase in elevation for 1981 cars without spark compensation (1.7 RON) was between the average reductions observed for 1977 cars (1.1 RON) and 1971-1972 cars (1.9 RON). However, the reduction for 1981 cars with spark compensation (0.6 RON) was about one-half as much.

* 50% refers to the 50th percentile acceleration technique.

** Research Octane Number

II. INTRODUCTION

The last CRC altitude octane program was conducted in 1977. It was found that the octane requirements of vehicles decreased substantially at high altitude compared with the requirements at sea level. In the past, octane requirements of engines have decreased with increasing altitude, primarily because of three factors: carburetor enrichment; less vacuum spark advance (weaker vacuum signal); and reduced charge density with decreasing barometric pressure. Accordingly, gasolines sold in high-altitude locations may have lower octane quality than those sold at sea level. Many of the 1981 model vehicles are equipped with electronic systems for controlling air-fuel mixture and spark timing, and the use of such systems may become more common in future model years. With these systems, air-fuel mixtures at part-throttle are controlled near stoichiometric regardless of altitude, and spark timing may be advanced as barometric pressure decreases. It was anticipated, therefore, that octane requirements of 1981 vehicles may not decrease as much with increasing altitude as had been observed with previous model cars.

This program was run to determine the effect of altitude on octane requirements of 1981 cars, particularly those with electronic control of air-fuel mixture and spark timing, and to provide technical data for ASTM (American Society for Testing and Materials) to consider for possible adjustment of the D 439 altitude octane specifications for gasoline.

Representatives from eleven companies, listed in Appendix A, participated in the test program. This report was prepared by the CRC Altitude Octane Requirement Program Analysis Panel of the CRC Road Test Group, membership of which is listed in Appendix B. The detailed test program is included in Appendix C.

III. CARS TESTED

A. Selection

Selection of the vehicles for this test program was based on the availability of vehicles in Los Angeles and Denver. Selected models encompassed expected future electronic engine controls that are currently available on some models, including: feedback air-fuel control; electronic spark timing; and barometrically compensated spark timing. Eight 1981 models were chosen, and all but six vehicles, which were supplied by the manufacturer, were obtained from rental agencies. All but eight cars had accumulated at least 6,000 miles prior to the test program.

The following models were tested:

Sample Size	Car Model	Engine	Engine Controls
10	Buick Skylark	2.5L - 2V	CLAF, EST
10	Buick Skylark/ Oldsmobile Omega	2.8L - 2V	CLAF, EST
10	Buick Regal/ Oldsmobile Cutlass	3.8L - 2V	BARO, CLAF, EST
3	Buick Electra/ Cadillac Fleetwood	4.1L - 4V	BARO, CLAF, EST, ESC
3	Buick Riviera/ Cadillac El Dorado/ Oldsmobile Toronado	4.1L - 4V	BARO, CLAF, EST
10	Dodge Aries	2.2L - 2V	CLAF, EST
10	Lincoln/Mark VI	5.0L - TBI	BARO, CLAF, EST
10	Mercury Capri	2.3L - 2V	CLAF
10	Toyota Corolla	1.8L - 2V	CLAF

NOTE: BARO = Barometrically Compensated Spark Timing
CLAF = Closed-Loop Air-Fuel Control
EST = Electronic Spark Timing
TBI = Throttle Body Injection
ESC = Electronic Spark Control with Knock Sensor

B. Preparation and Instrumentation

All vehicles were instrumented with a vacuum gauge and auxiliary fuel supply lines. Idle speed and spark timing were checked and reset to manufacturer specifications when necessary. Additional details concerning car preparation are contained in the test technique.

IV. REFERENCE FUELS

Octane requirements were measured at both altitudes using the FBRU and FBRSU series of 1981 CRC unleaded full-boiling range fuels. Average laboratory octane number ratings and blending data for these fuels are shown in Tables D-I and D-II of Appendix D. Inspection and composition data furnished by the fuel supplier are shown in Tables D-III and D-IV, respectively.

A. Unleaded Average Sensitivity Full-Boiling Range (FBRU) Reference Fuels

FBRU fuels were prepared from three base blends (RMFD 332-81, RMFD 333-81, and RMFD 334-81) in two octane number increments from 78 to 84 RON, and in one octane number increments from 84 to 100 RON.

B. Unleaded High Sensitivity Full-Boiling Range (FBRSU) Reference Fuels

FBRSU fuels were prepared from three base blends (RMFD 335-81, RMFD 336-81, and RMFD 337-81) in two octane number increments from 78 to 84 RON, and in one octane number increments from 84 to 101 RON.

V. TEST TECHNIQUE

Octane requirements were determined according to procedures outlined in the CRC E-15-81 technique (Appendix C, Attachment 1). Incidence of knock on tank fuel was not investigated, and octane requirements over the speed range on Primary Reference (PR) fuels were not determined in this program. Vehicle testing was conducted in the following sequence:

1. Octane requirements of all seventy-six cars were determined in Denver, Colorado.
2. After requirements were determined in Denver, all cars were transported by truck to Los Angeles, California.
3. Octane requirements were determined in Los Angeles.

VI. TEST FACILITIES

The sea-level portion of the program was based at the Union Oil Research Center in Brea, California; and vehicle tests were conducted on Santa Ana Canyon Road in Anaheim, California, at an elevation of 325 feet.

The high-altitude tests were conducted in Denver, Colorado, at an elevation of 5,280 feet. Vehicle tests were run on Smith Road, which was used for the 1977 program; and the General Motors Vehicle Emissions Test Facility was used as the base of operations.

VII. WEATHER CONDITIONS

Ambient weather conditions were recorded for each octane rating. The range and mean values of barometric pressure, absolute humidity, and ambient temperature for each car group are listed in Appendix E, Tables E-I, E-II, and E-III, respectively. A summary of these data for all cars is as follows:

	Barometric Pressure, in.Hg		
	High	Low	Mean
Los Angeles(1)	29.73	29.42	29.65
Denver(2)	24.80	24.53	24.68

	Absolute Humidity grains H_2O/lb Dry Air		
	High	Low	Mean
Los Angeles	92	26	68
Denver	96	52	76

	Ambient Temperature, °F		
	High	Low	Mean
Los Angeles	110	68	88
Denver	95	68	80

VIII. DISCUSSION OF RESULTS

A. General

Octane number requirements of individual cars determined in Los Angeles and in Denver are tabulated in Appendix F. For analysis, the test-car fleet was subdivided into seven groups of ten similar cars each. Each group of cars represented a specific vehicle and/or engine design. An eighth group of six cars was analyzed, and is treated separately.

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(1) 325 feet above sea level.

(2) 5,280 feet above sea level.

Because temperature and humidity varied widely between Los Angeles and Denver, all raw data were corrected to standard conditions of 70°F and 50 grains of humidity. Octane number requirements (ONR) were corrected by the following formula:

$$\text{Corrected ONR} = \text{ONR measured} + 0.054\,(70 - T) - 0.035\,(50 - H)$$

Where T and H are the temperature (°F) and humidity (gr) observed when the octane requirement was measured.

Temperature and humidity coefficients, 0.054 ON/°F and 0.035 ON/gr H_2O, were adopted from Section A.1.3.6 of the 1981 ASTM D 439 Automotive Gasoline Specifications. ONR values of 1981 cars were not corrected for variations in barometric pressure because:

(1) the variation in barometric pressure in both Los Angeles and Denver during the 1981 program was small (± 0.3 inches Hg); and

(2) the difference between the average barometric pressure in Los Angeles and Denver approximated the standard atmospheric pressure lapse rate; i.e., 1.0 inch Hg per 1,000 feet of altitude.

Both uncorrected and corrected octane requirements of individual cars are summarized in Appendix G.

B. Octane Number Requirements in Los Angeles vs. Octane Number Requirements in Denver

1. Car Groups 1-7

Individual car group raw and weather-corrected data were averaged for both Los Angeles and Denver. The data are summarized for maximum and 50th percentile acceleration technique requirements with FBRU fuel (Tables I and II) and for maximum requirements with FBRSU fuel (Table III). In addition to the individual car groups, averages for compensated cars (barometrically compensated spark timing - Groups 2 and 4) and non-compensated cars (Groups 1, 3, 5, 6, and 7) are also shown.

Using the FBRU maximum requirement data, the mean octane requirement for non-compensated cars was 8.2 RON (7.3 RON weather-corrected) higher in Los Angeles than in Denver, while the compensated cars only differed by an average of 3.2 RON (2.5 RON weather-corrected).

Except as noted, all octane requirement differences were statistically significant at the 95 percent confidence level. The lesser change in octane requirements for the compensated cars is illustrated in Figure 1 for maximum and 50th percentile acceleration technique requirement conditions. This figure also shows that the change attributable to altitude is approximately the same, independent of driving condition or sensitivity of the fuel. The weather-corrected data are shown in Figure 2.

Car-to-car variations within individual car groups for FBRU maximum requirements are illustrated in Figures 3 and 4. The data ranged from 2 RON (Group 4 - Denver) to 16 RON (Group 7 - Denver). Although octane requirements vary widely within some car groups, the effect of altitude can be ascertained because individual cars were rated in both Los Angeles and Denver. The differences in mean octane requirements for each car group (Los Angeles versus Denver) are statistically significant at the 95 percent confidence level.

2. Car Group 8

In addition to the seven groups of ten cars each, another group of six cars was tested. All six cars had the same basic engine with barometrically compensated spark timing. Three of these cars had ESC systems with knock sensors (Group 8B), and the other three (Group 8A) did not. Octane requirements with FBRU fuels are listed in Tables IV and V, and with FBRSU fuels in Table VI.

For the cars with knock sensors, the minimum, maximum, and E-15 octane requirements (described in Appendix C, Attachment 1) at Los Angeles are compared with those at Denver in Figure 5. The increase in altitude reduced average octane requirements approximately 2 to 4 RON on a raw-data basis, and 2 to 5 RON on a weather-corrected basis. These reductions are similar to those shown in Figures 1 and 2 for compensated cars.

For the companion cars without knock sensors, the E-15 octane requirements at Los Angeles are compared with those at Denver in Figure 6. The increase in altitude reduced average octane requirements approximately 8 to 9 RON on a raw-data basis, and 7 to 8 RON on a weather-corrected basis. These reductions were much larger than those observed with the knock sensor cars (Figure 5) or the other compensated cars (Figures 1 and 2). In fact, the reductions were similar to those for the non-compensated cars shown in Figures 1 and 2. Because these cars were equipped with barometrically compensated spark timing, this anomalous behavior was not expected and cannot be explained from these data.

The variations in FBRU requirements (E-15) within car groups 8A and 8B are shown in Figures 3 and 4. The cars with knock sensors (Group 8B) had requirements which varied 6 RON in Los Angeles and 10 RON in Denver. The differences in the means were not significant at

the 95 percent confidence level. Similarly, the cars without knock sensors (Group 8A) had requirements which varied 6 RON in Los Angeles and 1 RON in Denver, and the differences in the means were significant at the 95 percent confidence level.

C. Distribution of Differences in Octane Number Requirements for Cars Tested at Los Angeles and Denver

The distribution of differences for the raw data are shown in Figures 7 through 13. The differences were determined by subtracting the octane requirements measured at Denver from those measured at Los Angeles for each individual car. The mean and standard deviation were determined for the differences in each car group.

The mean was plotted at the 50th percentile, and the mean plus the standard deviation was plotted at the 84th percentile. Using this procedure, a line drawn through these two points assumes a normal distribution.

Each plot contains three lines: maximum requirement for FBRU and FBRSU fuels, ard the 50th percentile acceleration technique requirement on FBRU fuels.

Data are not shown for car groups 8A and 8B because of the small sample sizes (only three cars per group), which precludes drawing mean ngful distribution curves.

D. Comparison of 1981 CRC Altitude Program With Previous Altitude Studies

Results from previous altitude programs are summarized in Table VII. All data are expressed as the change in ONR per 1,000 feet change in altitude (ΔONR/1,000 feet). Since data from previous programs were not weather-corrected, only the raw data from the 1981 cars are listed in Table VII so valid comparisons can be made among the various programs.

The ΔONR/1,000 feet for non-compensated 1981 model cars is 1.7 RON, or about the average ONR charge observed in cars tested in two previous CRC programs. The ΔONR/1,000 feet for 1977 cars and 1971-1972 cars was 1.1 RON and 1.9 RON, respectively. The ΔONR/1,000 feet for compensated cars, however, is only 0.6 RON, or about one-third to one-half the change observed in the two previous programs and with the non-compensated cars in the 1981 program.

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REFERENCES

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4. J. C. Ingamells, R. K. Stone, N. H. Gerber, and G. H. Unzelman, "Effects of Atmospheric Variables on Passenger Car Octane Number Requirements," SAE West Coast Meeting, August 1966.

5. Coordinating Research Council, Inc., "Effect of Altitude Changes on Octane Number Requirement of Late Model Cars," *CRC Report No. 454,* October 1973.

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TABLES

AND

FIGURES

TABLE I

FBRU MAXIMUM REQUIREMENTS

CAR GROUPS 1-7

Group	Raw Data LA	Raw Data Denver	Raw Data Difference	Weather-Corrected Data LA	Weather-Corrected Data Denver	Weather-Corrected Data Difference
			RON*			
1	88.7	81.5	7.2	88.2	81.9	6.3
2	90.6	87.6	3.0	90.4	87.8	2.6
3	88.9	80.2	8.7	87.7	80.8	6.9
4	94.1	90.7	3.4	93.5	91.1	2.4
5	92.7	83.5	9.2	92.0	84.4	7.6
6	93.2	84.2	9.0	93.4	84.7	8.7
7	94.7	87.6	7.1	94.8	87.5	7.3
Avg, All Cars	91.8	85.1	6.7	91.4	85.5	6.0
Avg, Compensated Cars (2 & 4)	92.4	89.2	3.2	92.0	89.5	2.5
Avg, Non-Compensated Cars (1,3,5,6, & 7)	91.6	83.4	8.2	91.2	83.9	7.3
			(RON + MON)/2*			
1	85.3	79.6	5.7	84.9	80.0	4.9
2	86.7	84.4	2.3	86.6	84.5	2.1
3	85.4	78.6	6.8	84.5	79.1	5.4
4	89.6	86.9	2.7	89.1	87.2	1.9
5	88.5	81.2	7.3	87.9	81.9	6.0
6	88.9	81.7	7.2	89.1	82.1	7.0
7	90.1	84.4	5.7	90.2	84.3	5.9
Avg, All Cars	87.8	82.4	5.4	87.5	82.7	4.8
Avg, Compensated Cars (2 & 4)	88.2	85.7	2.5	87.9	85.9	2.0
Avg, Non-Compensated Cars (1,3,5,6, & 7)	87.6	81.1	6.5	87.3	81.5	5.8

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* RON = Research Octane Number

MON = Motor Octane Number

TABLE II

FBRU 50TH PERCENTILE ACCELERATION TECHNIQUE REQUIREMENTS

CAR GROUPS 1-7

Group	Raw Data LA	Raw Data Denver	Raw Data Difference	Weather-Corrected Data LA	Weather-Corrected Data Denver	Weather-Corrected Data Difference
			RON			
1	88.2	79.7	8.5	87.8	80.1	7.7
2	90.0	87.0	3.0	89.8	87.2	2.5
3	88.5	79.7	8.8	87.3	80.3	7.0
4	92.8	90.5	2.3	92.2	90.8	1.4
5	92.9	82.8	10.1	92.1	83.7	8.4
6	93.4	84.4	9.0	93.5	84.9	8.6
7	94.6	87.3	7.3	94.7	87.2	7.5
Avg , All Cars	91.5	84.5	7.0	91.1	84.9	6.2
Avg , Compensated Cars (2 & 4)	91.4	88.8	2.6	91.0	89.0	2.0
Avg , Non-Compensated Cars (1,3,5,6, & 7)	91.5	82.8	8.7	91.1	83.2	7.9
			(RON + MON)/2			
1	84.9	78.2	6.7	84.6	78.5	6.1
2	86.3	83.9	2.4	86.1	84.1	2.0
3	85.1	78.2	6.9	84.2	78.7	5.5
4	88.6	86.7	1.9	88.1	86.9	1.2
5	88.7	80.7	8.0	88.0	81.4	6.6
6	89.1	81.9	7.2	89.1	82.3	6.8
7	90.0	84.2	5.8	90.1	84.1	5.9
Avg , All Cars	87.5	82.0	5.5	87.2	82.3	4.9
Avg , Compensated Cars (2 & 4)	87.4	85.3	2.1	87.1	85.5	1.6
Avg , Non-Compensated Cars (1,3,5,6, & 7)	87.6	80.6	7.0	87.2	81.0	6.2

TABLE III

FBRSU MAXIMUM REQUIREMENTS
CAR GROUPS 1-7

Group	Raw Data LA	Raw Data Denver	Raw Data Difference	Weather-Corrected Data LA	Weather-Corrected Data Denver	Weather-Corrected Data Difference
			RON			
1	89.9	82.6	7.3	89.5	83.0	6.5
2	92.4	89.2	3.2	92.2	89.4	2.8
3	90.1	82.0	8.1	88.9	82.6	6.3
4	95.2	91.9	3.3	94.6	92.2	2.4
5	93.5	84.9	8.6	92.7	85.8	6.9
6	94.3	85.8	8.5	94.5	86.3	8.2
7	95.8	88.5	7.3	95.9	88.4	7.5
Avg, All Cars	93.0	86.4	6.6	92.6	86.8	5.8
Avg, Compensated Cars (2 & 4)	93.8	90.6	3.2	93.4	90.8	2.6
Avg, Non-Compensated Cars (1,3,5,6, & 7)	92.7	84.8	7.9	92.3	85.2	7.1
			(RON + MON)/2			
1	85.3	79.1	6.2	85.0	79.4	5.6
2	87.4	84.7	2.7	87.2	84.9	2.3
3	85.4	78.6	6.8	84.4	79.1	5.3
4	89.8	87.0	2.8	89.2	87.2	2.0
5	88.3	81.0	7.3	87.6	81.8	5.8
6	89.0	81.8	7.2	89.2	82.3	6.9
7	90.3	84.1	6.2	90.4	84.0	6.4
Avg, All Cars	87.9	82.3	5.6	87.6	82.7	4.9
Avg, Compensated Cars (2 & 4)	88.6	85.8	2.8	88.2	86.0	2.2
Avg, Non-Compensated Cars (1,3,5,6, & 7)	87.7	80.9	6.8	87.3	81.3	6.0

TABLE IV

FBRU REQUIREMENTS
CAR GROUPS 8A AND 8B

Group	Raw Data LA	Raw Data Denver	Raw Data Difference	Weather-Corrected Data LA	Weather-Corrected Data Denver	Weather-Corrected Data Difference
			RON			
8A (E-15)	90.7	81.7	9.0	90.2	82.1	8.1
8B (E-15)	96.3	93.0	3.3	96.8	93.1	3.7
8B (Minimum)	87.3	83.3	4.0	87.8	83.4	4.4
8B (Maximum)	98.3	94.7	3.7	98.8	94.7	4.0
			(RON + MON)/2			
8A (E-15)	86.9	79.6	7.3	86.5	80.1	6.4
8B (E-15)	91.3	88.7	2.6	91.7	88.8	2.9
8B (Minimum)	84.2	81.0	3.2	84.6	81.1	3.5
8B (Maximum)	93.0	90.1	2.9	93.7	90.0	3.7

TABLE V

FBRU 50TH PERCENTILE ACCELERATION TECHNIQUE REQUIREMENTS

CAR GROUPS 8A AND 8B

Group	Raw Data LA	Raw Data Denver	Raw Data Difference	Weather-Corrected Data LA	Weather-Corrected Data Denver	Weather-Corrected Data Difference
			RON			
8A (E-15)	89.2	81.0	8.2	88.7	81.4	7.3
8B (E-15)	96.0	93.0	3.0	96.4	93.1	3.4
8B (Minimum)	87.0	82.7	4.3	87.4	82.7	4.7
8B (Maximum)	97.7	96.0	1.7	98.1	96.1	2.0
			(RON + MON)/2			
8A (E-15)	85.8	79.0	6.8	85.4	79.4	6.0
8B (E-15)	91.0	88.7	2.3	91.4	88.8	2.6
8B (Minimum)	84.0	80.5	3.5	84.3	80.5	3.8
8B (Maximum)	92.5	91.0	1.5	92.8	91.1	1.7

TABLE VI

FBRSU REQUIREMENTS
CAR GROUPS 8A AND 8B

Group	Raw Data LA	Raw Data Denver	Raw Data Difference	Weather-Corrected Data LA	Weather-Corrected Data Denver	Weather-Corrected Data Difference
RON						
8A (E-15)	93.3	84.3	9.0	92.9	84.8	8.1
8B (E-15)	97.0	95.0	2.0	97.4	95.1	2.4
8B (Minimum)	86.3	84.0	2.3	86.8	84.1	2.7
8B (Maximum)	99.7	97.0	2.7	100.1	97.1	3.0
(RON + MON)/2						
8A (E-15)	88.1	80.6	7.5	87.8	81.0	6.8
8B (E-15)	91.3	89.6	1.7	91.6	89.7	1.9
8B (Minimum)	82.3	80.3	2.0	82.7	80.4	2.3
8B (Maximum)	93.6	91.3	2.3	93.9	91.4	2.5

TABLE VII

COMPARISON OF RESULTS FROM 1981 CRC ALTITUDE PROGRAM WITH THOSE FROM PREVIOUS ALTITUDE PROGRAMS (RAW DATA)

Source	Ref.* No.	Cars No.	Cars Model Year	Reference Fuel	ΔONR/ 1,000 Ft, RON	
Ethyl	1	5	1949	FBR & PR	2.4	
Exxon	2	3	1954-1955	PR	2.8	
Amoco	3	8	1961	FBR	1.2	
Chevron & Ethyl	4	8	1965	FBR & PR	1.5	
1972 CRC Altitude Program	5	6	1967-1970	AU-8	1.2	
		6	1967-1970	PR	1.2	
		39	1971-1972	AU-8	1.9	
		39	1971-1972	PR	1.7	
1977 CRC Altitude Program	6	24	1977	FBRU	1.1	
			1977	PR	1.0	
					RON	(R+M)/2
1981 CRC Altitude Program		50	1981 NC	FBRU Max.	1.7	1.3
			1981 NC	+FBRU 50%	1.8	1.4
			1981 NC	FBRSU Max.	1.6	1.4
		20	1981 C	FBRU Max.	0.6	0.5
			1981 C	+FBRU 50%	0.5	0.4
			1981 C	FBRSU Max.	0.6	0.6

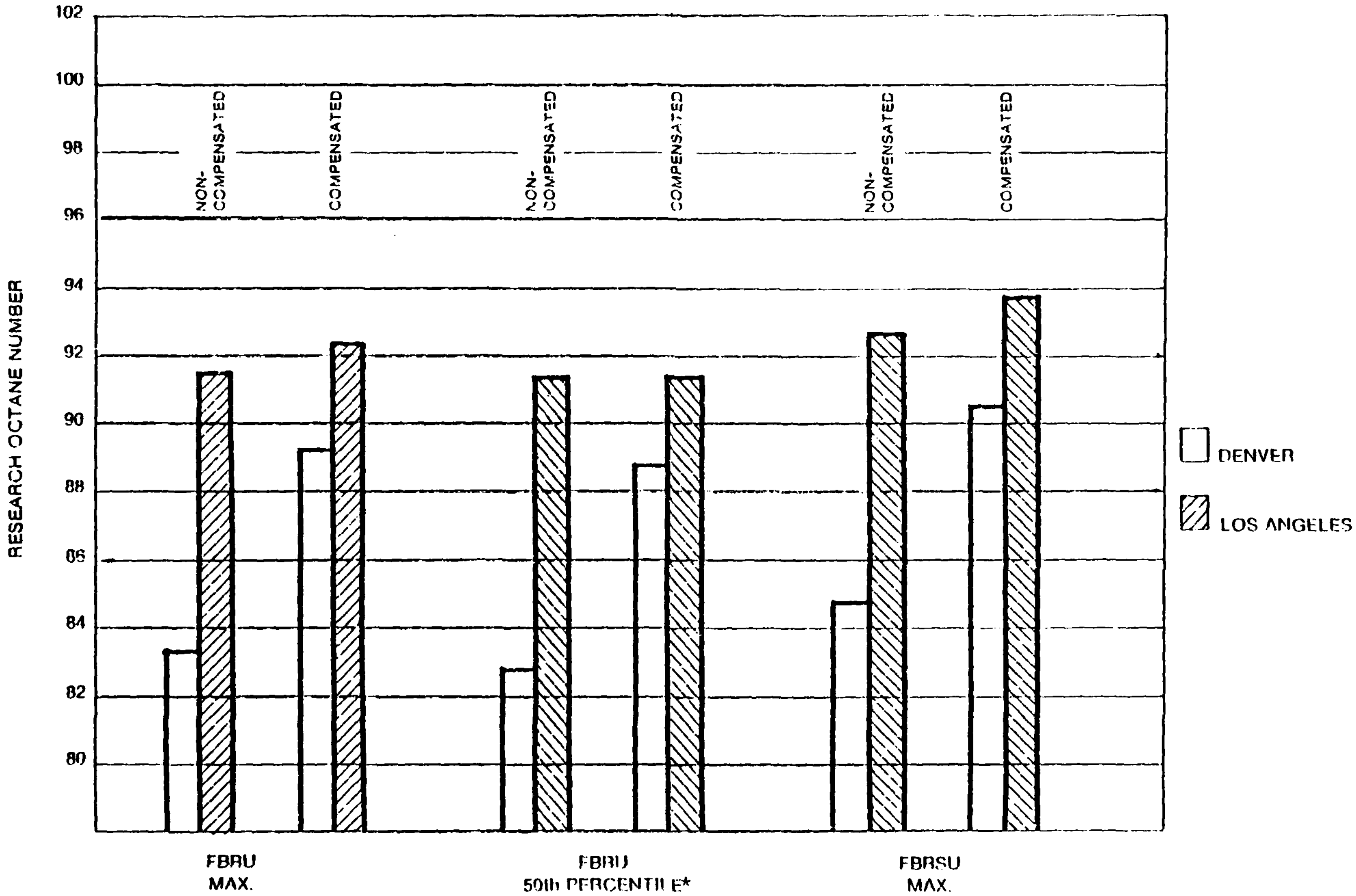
NC = Non-Compensated
C = Barometric Pressure Compensated Spark Timing

*References listed on page 11 of this report.

+50th Percentile Acceleration Technique

FIGURE 1

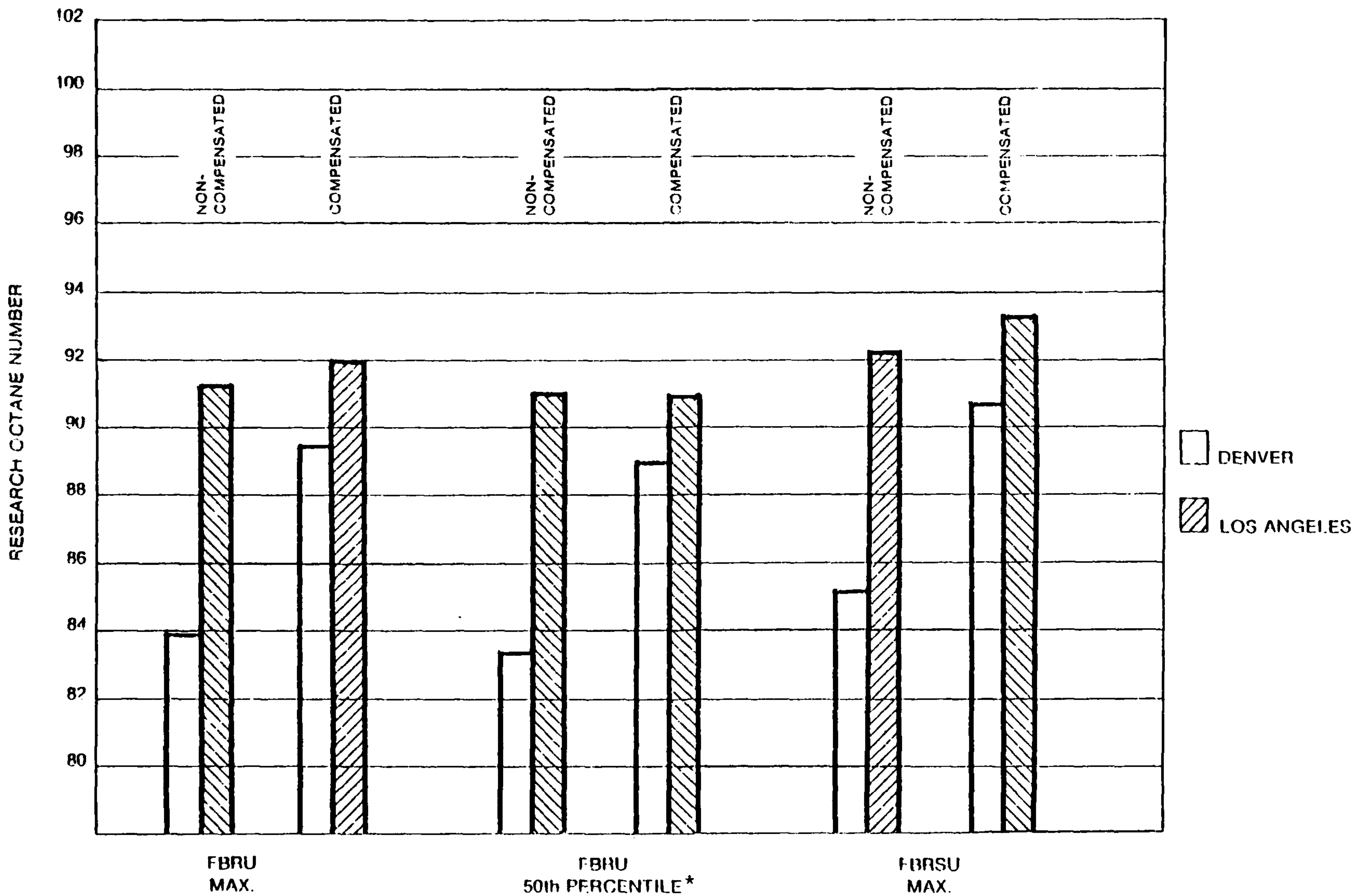
AVERAGE OCTANE REQUIREMENTS OF COMPENSATED CARS COMPARED WITH THOSE OF NON-COMPENSATED CARS--RAW DATA



* 50th Percentile Acceleration Technique

FIGURE 2

AVERAGE OCTANE REQUIREMENTS OF COMPENSATED CARS COMPARED WITH THOSE OF NON-COMPENSATED CARS—WEATHER-CORRECTED DATA



* 50th Percentile Acceleration Technique

FIGURE 3

RANGE IN INDIVIDUAL OCTANE REQUIREMENTS WITHIN EACH CAR GROUP TESTED IN DENVER

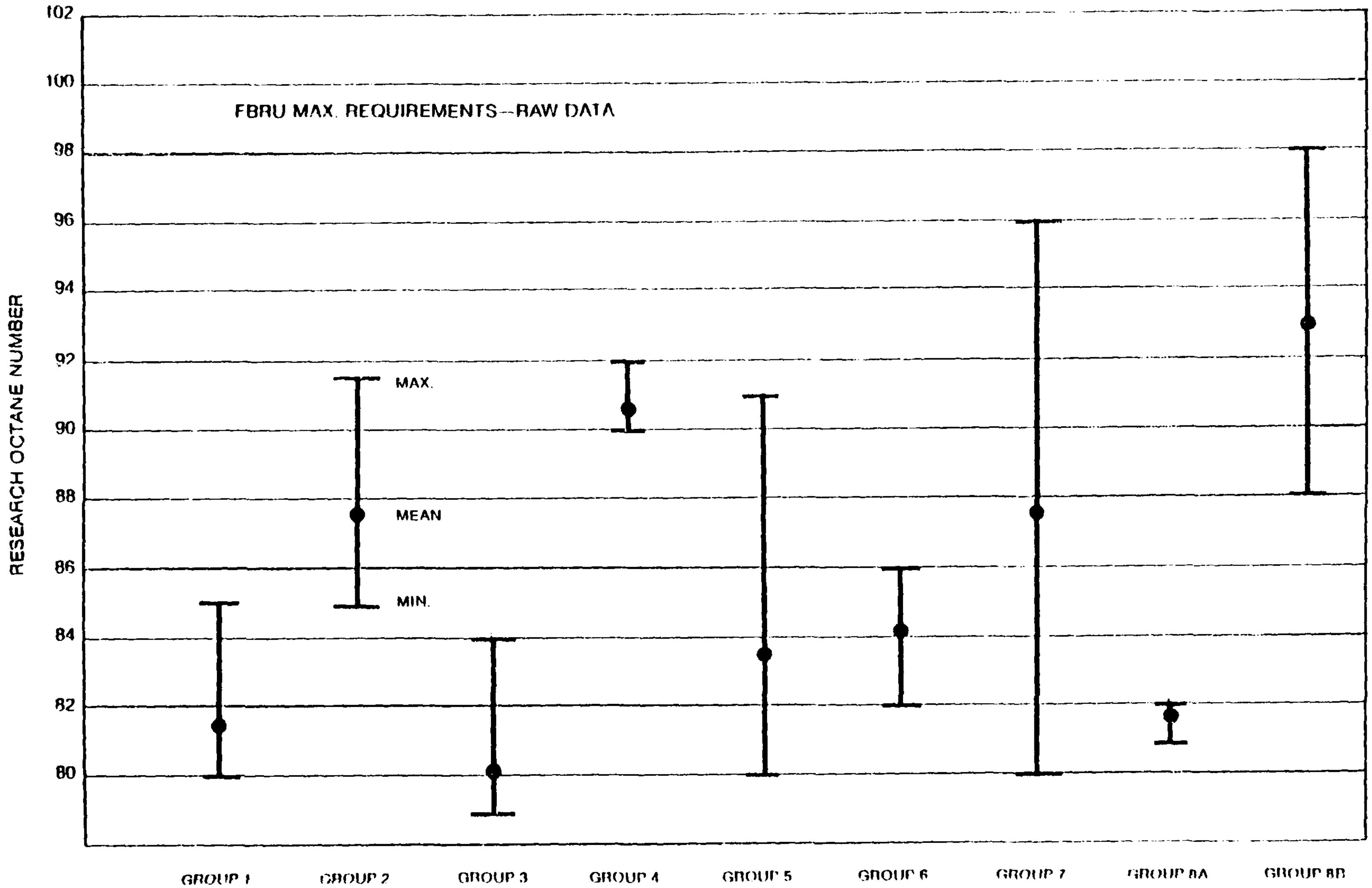


FIGURE 4

RANGE IN INDIVIDUAL OCTANE REQUIREMENTS WITHIN EACH CAR GROUP TESTED IN LOS ANGELES

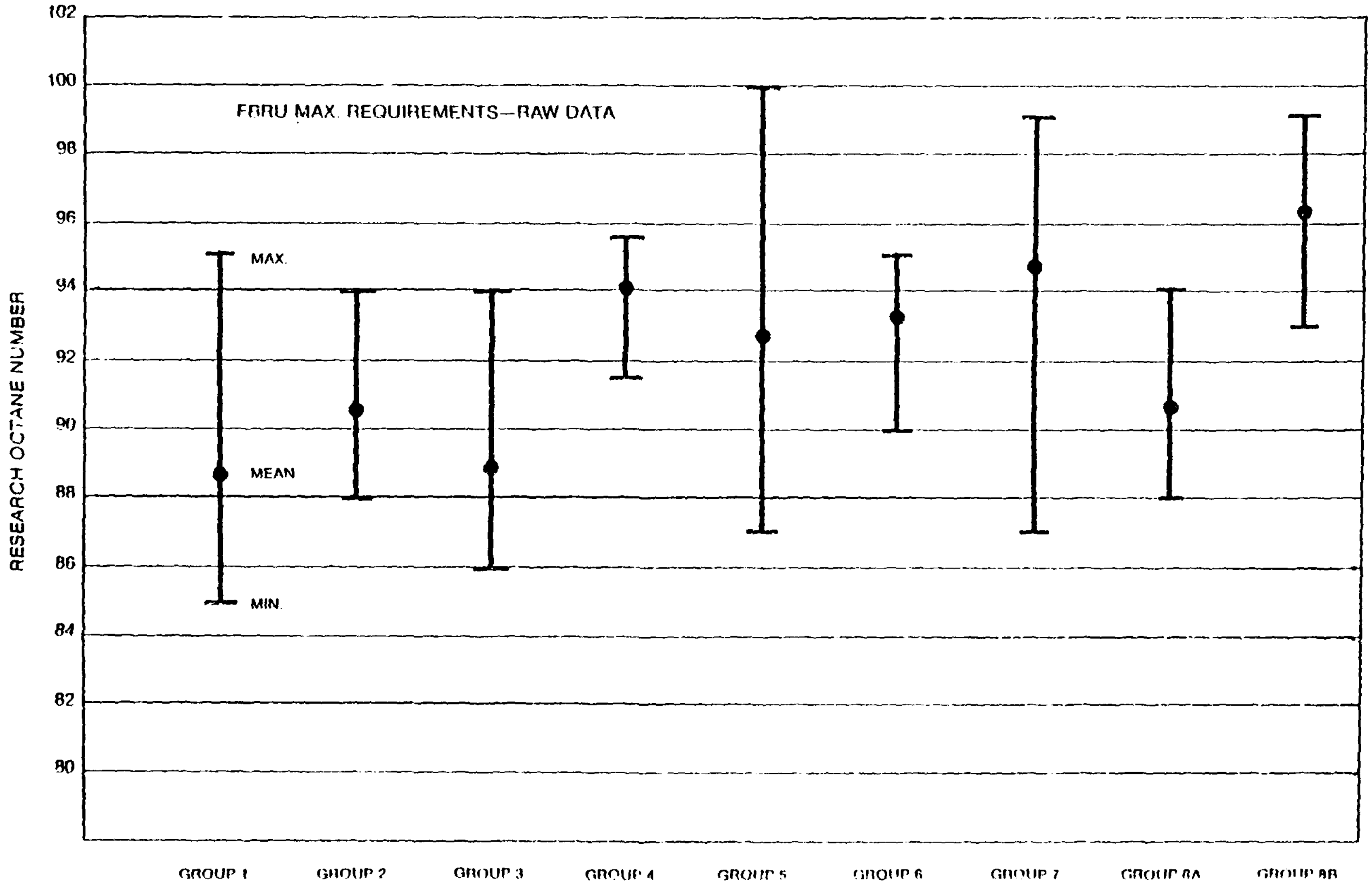
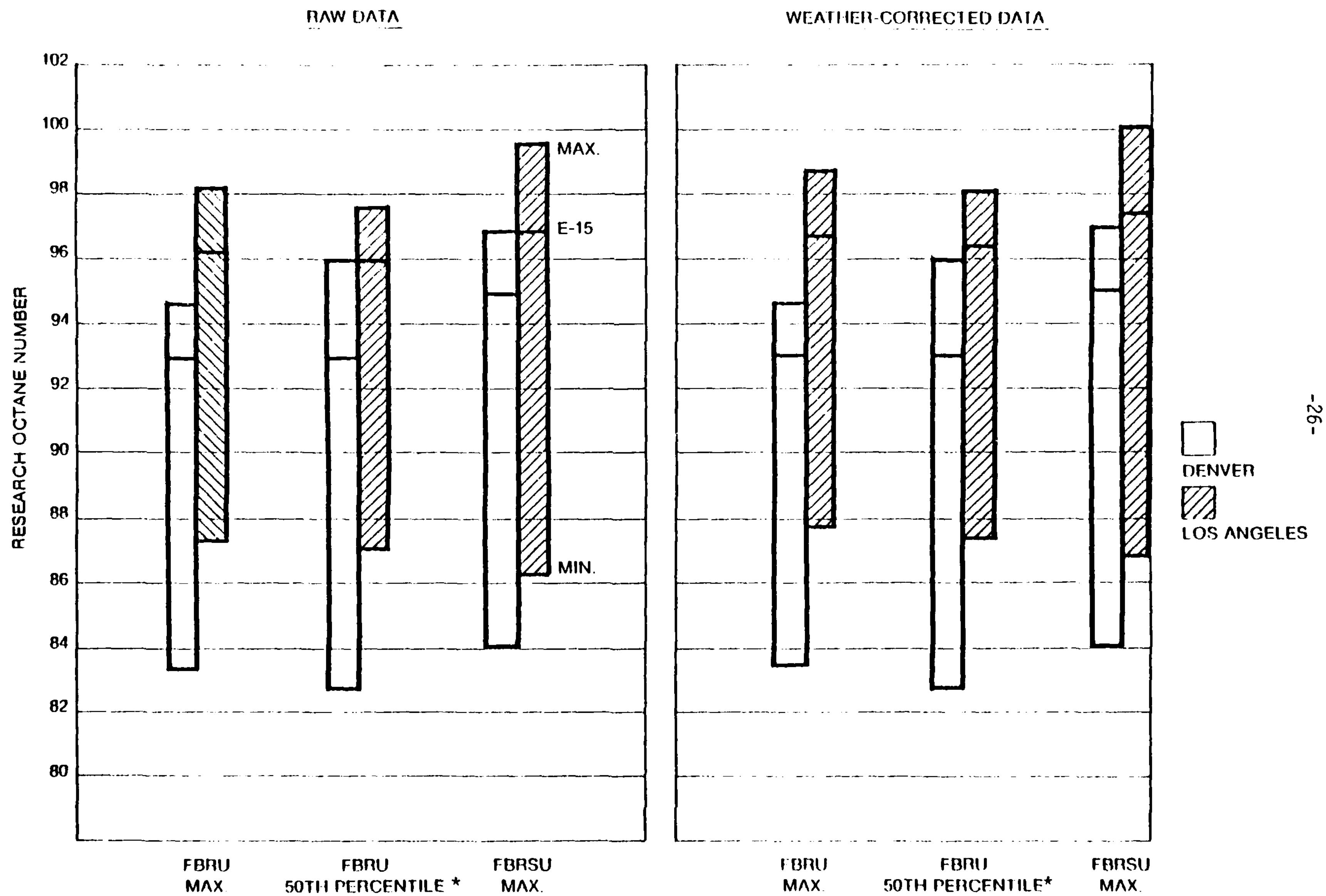


FIGURE 5

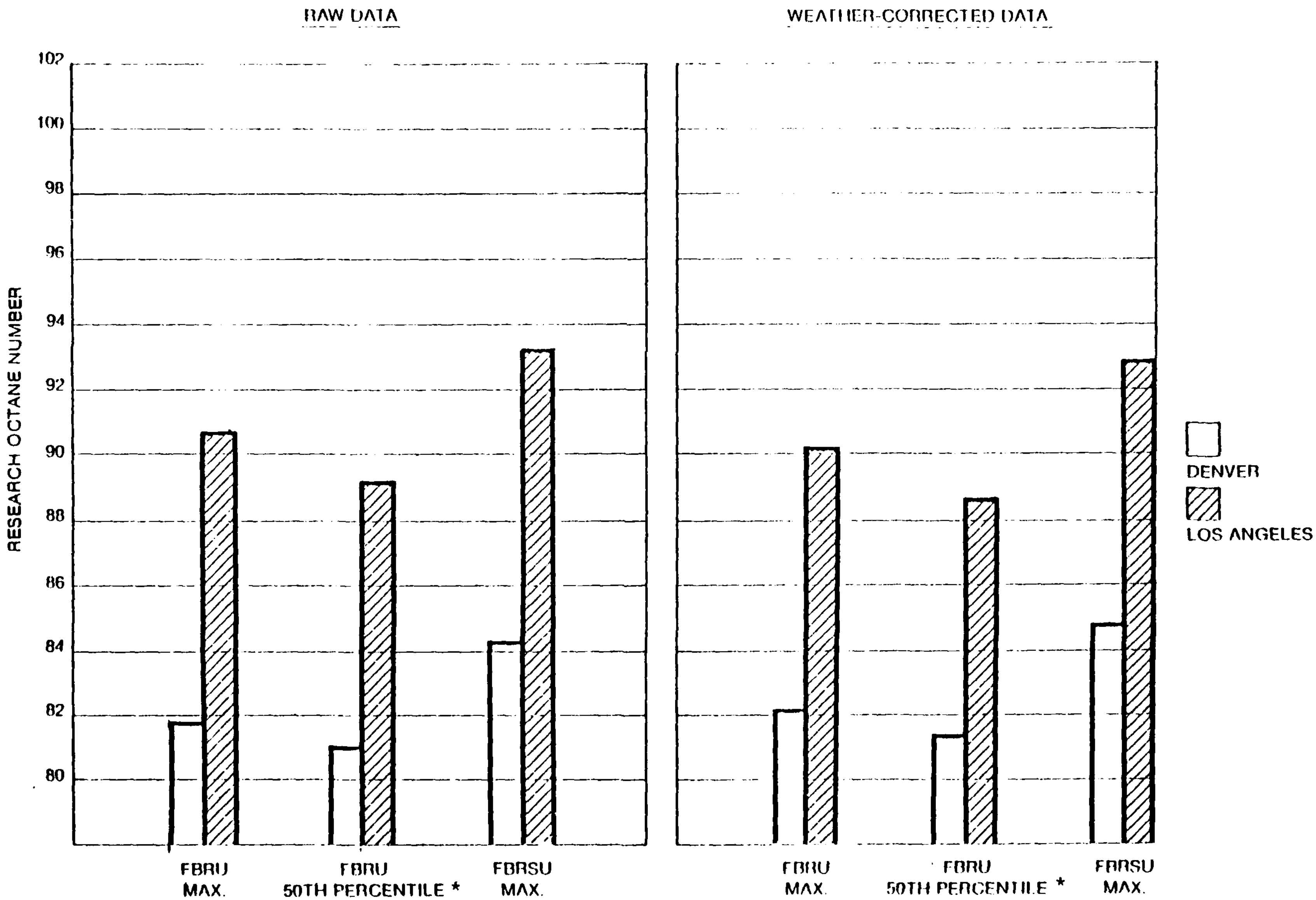
AVERAGE OCTANE REQUIREMENTS OF GROUP 8B CARS EQUIPPED WITH KNOCK SENSORS



* 50th Percentile Acceleration Technique

FIGURE 6

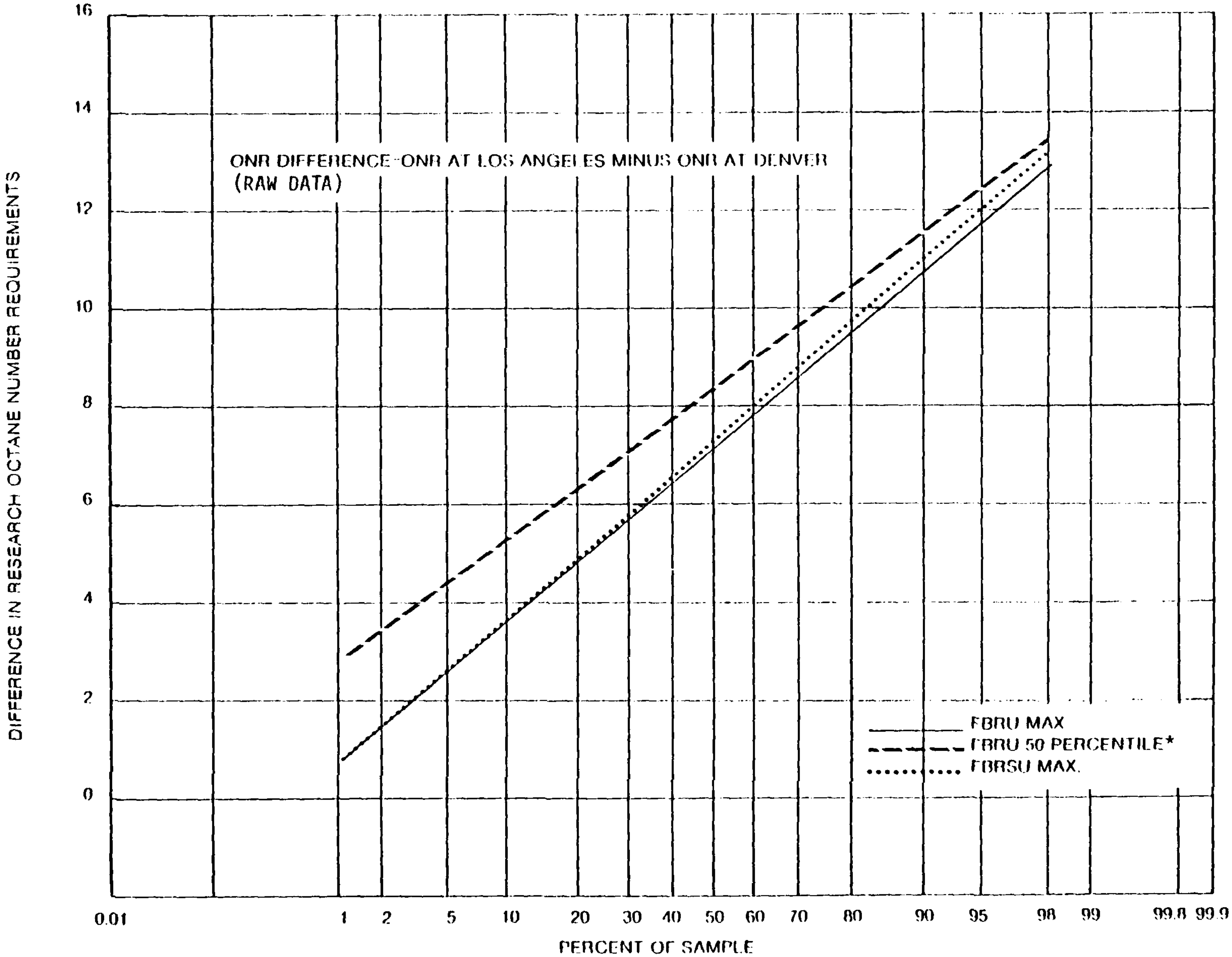
AVERAGE OCTANE REQUIREMENTS OF GROUP 8A CARS NOT EQUIPPED WITH KNOCK SENSORS



* 50th Percentile Acceleration Technique

FIGURE 7

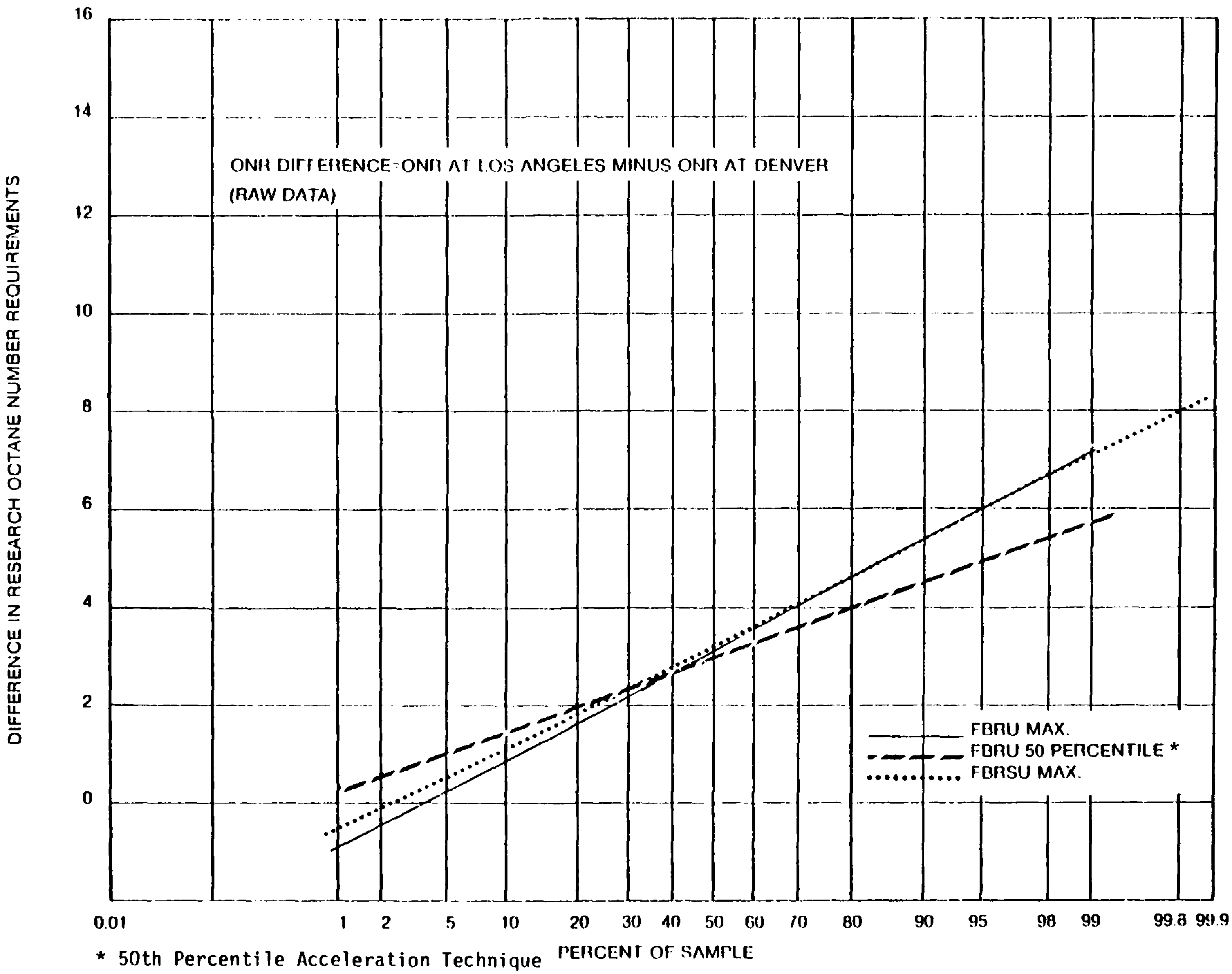
DISTRIBUTION OF DIFFERENCES IN OCTANE REQUIREMENTS - GROUP 1 CARS



* 50th Percentile Acceleration Technique

FIGURE 8

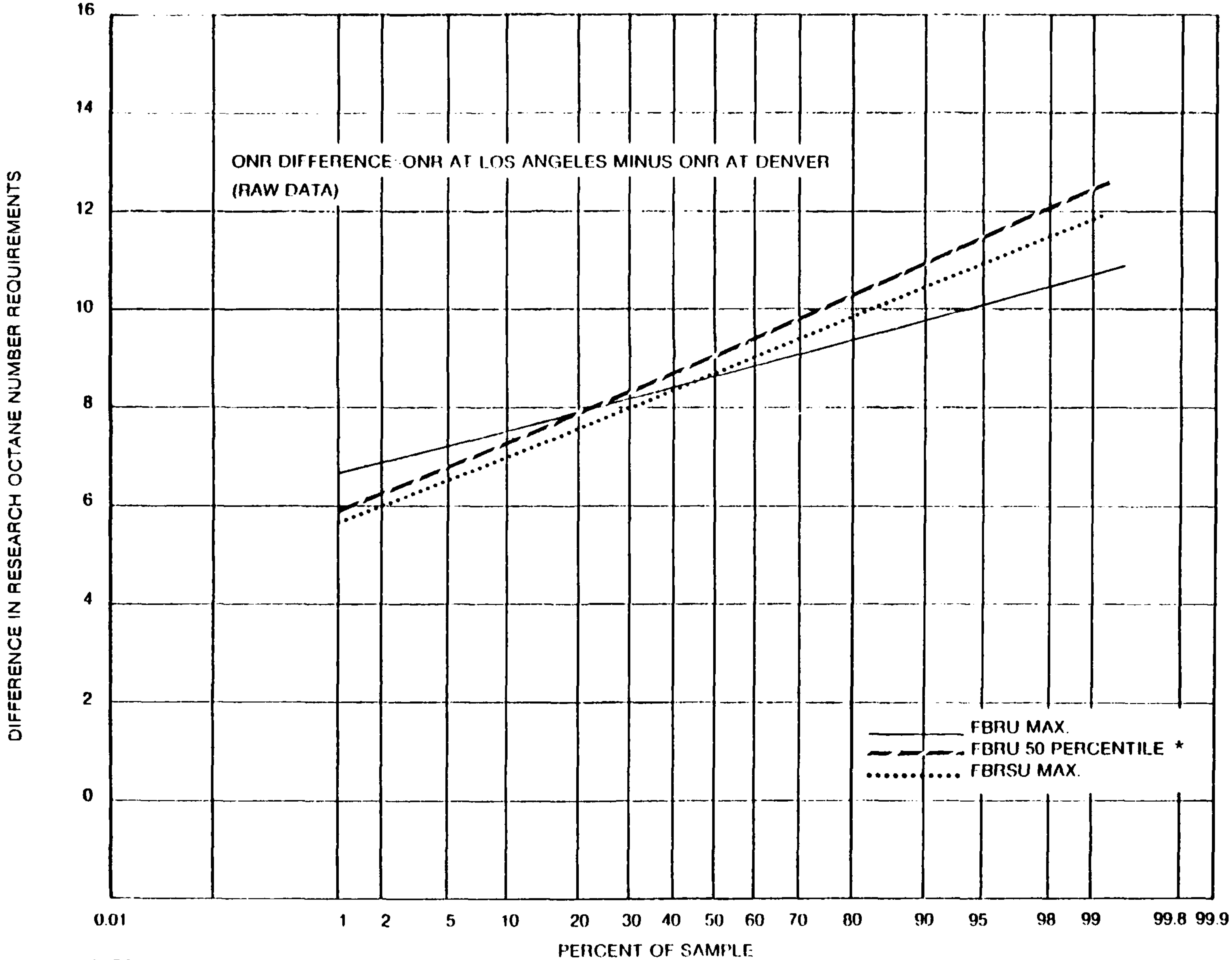
DISTRIBUTION OF DIFFERENCES IN OCTANE REQUIREMENTS—GROUP 2 CARS



* 50th Percentile Acceleration Technique

FIGURE 9

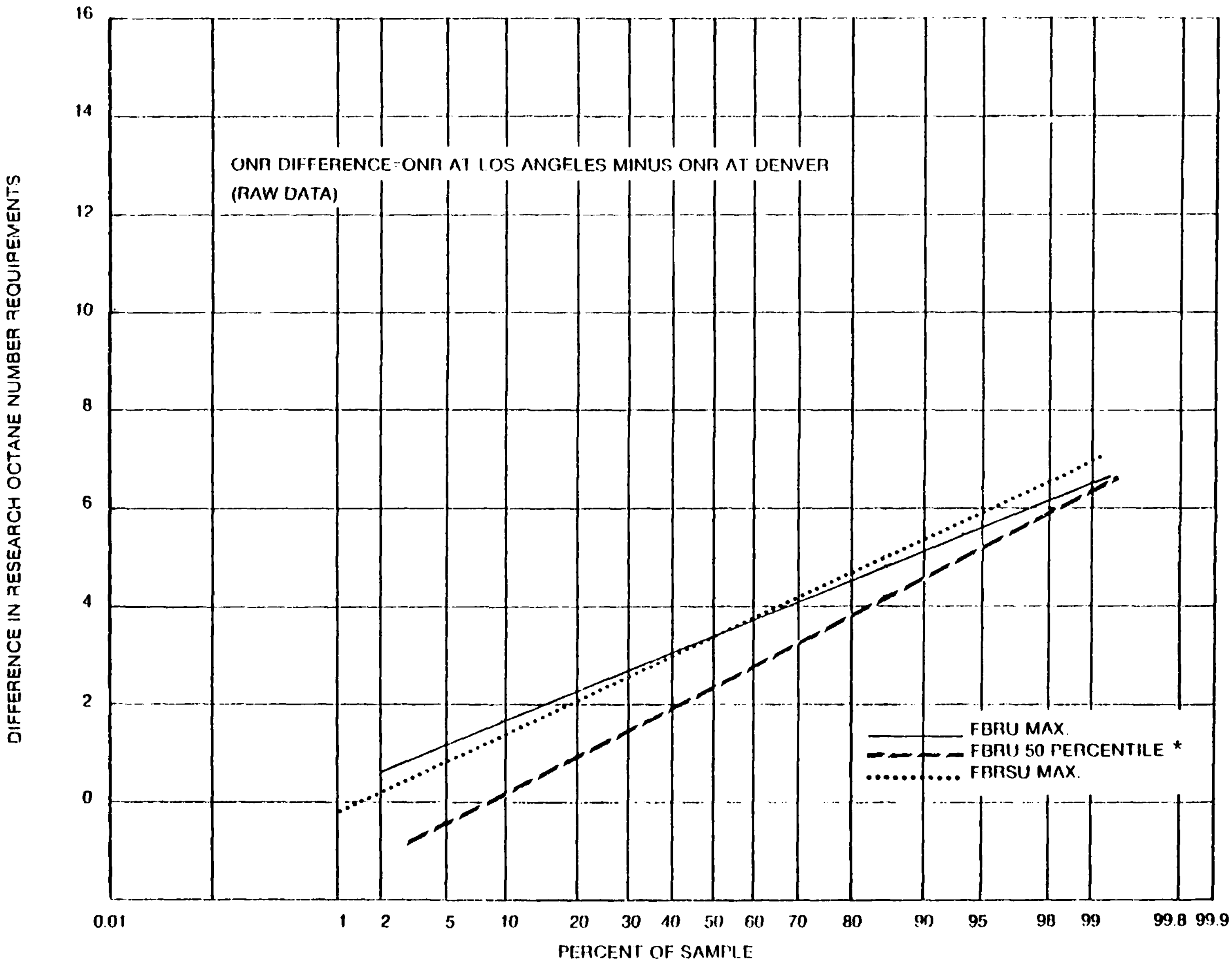
DISTRIBUTION OF DIFFERENCES IN OCTANE REQUIREMENTS—GROUP 3 CARS



* 50th Percentile Acceleration Technique

FIGURE 10

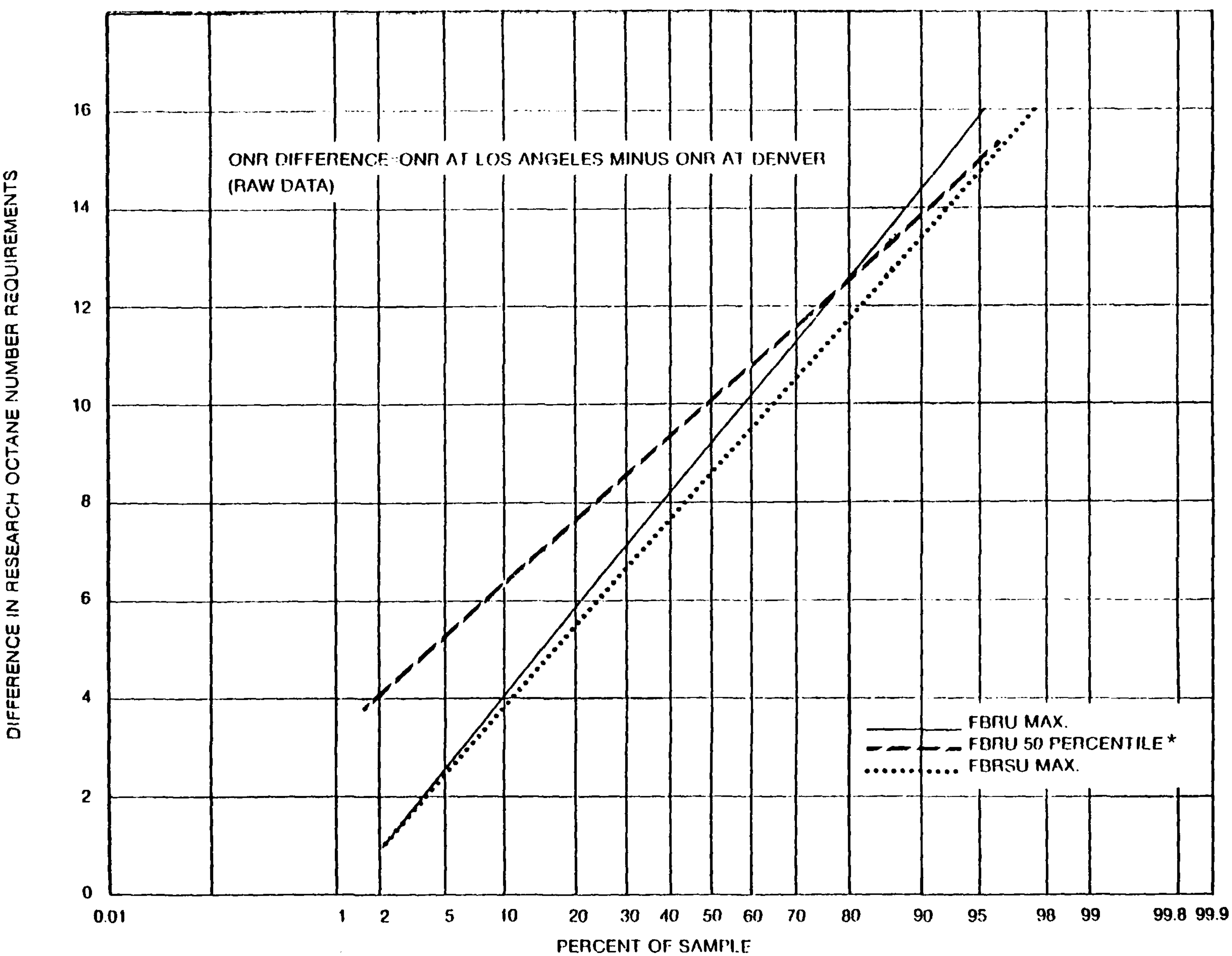
DISTRIBUTION OF DIFFERENCES IN OCTANE REQUIREMENTS - GROUP 4 CARS



* 50th Percentile Acceleration Technique

FIGURE 11

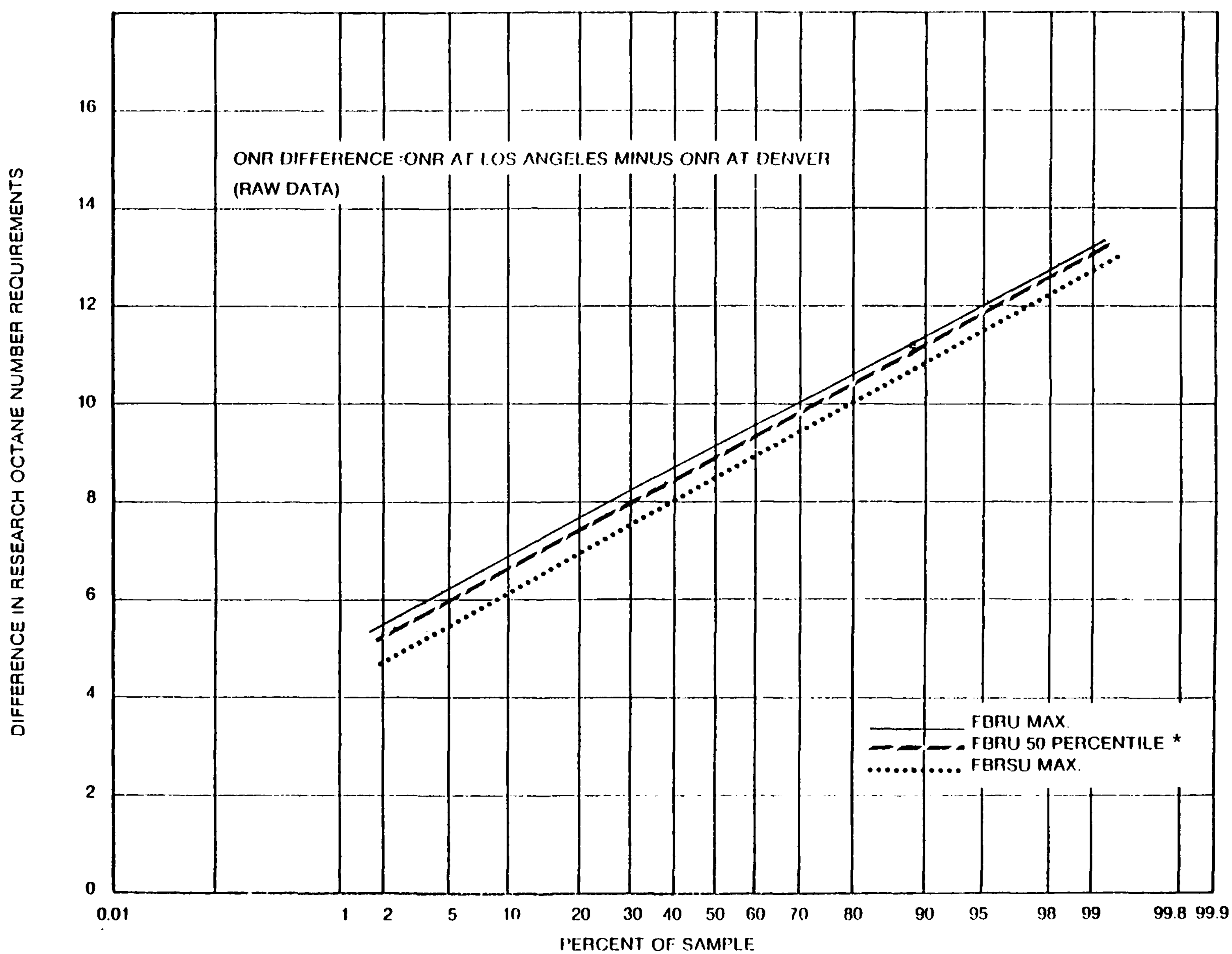
DISTRIBUTION OF DIFFERENCES IN OCTANE REQUIREMENTS—GROUP 5 CARS



* 50th Percentile Acceleration Technique

FIGURE 12

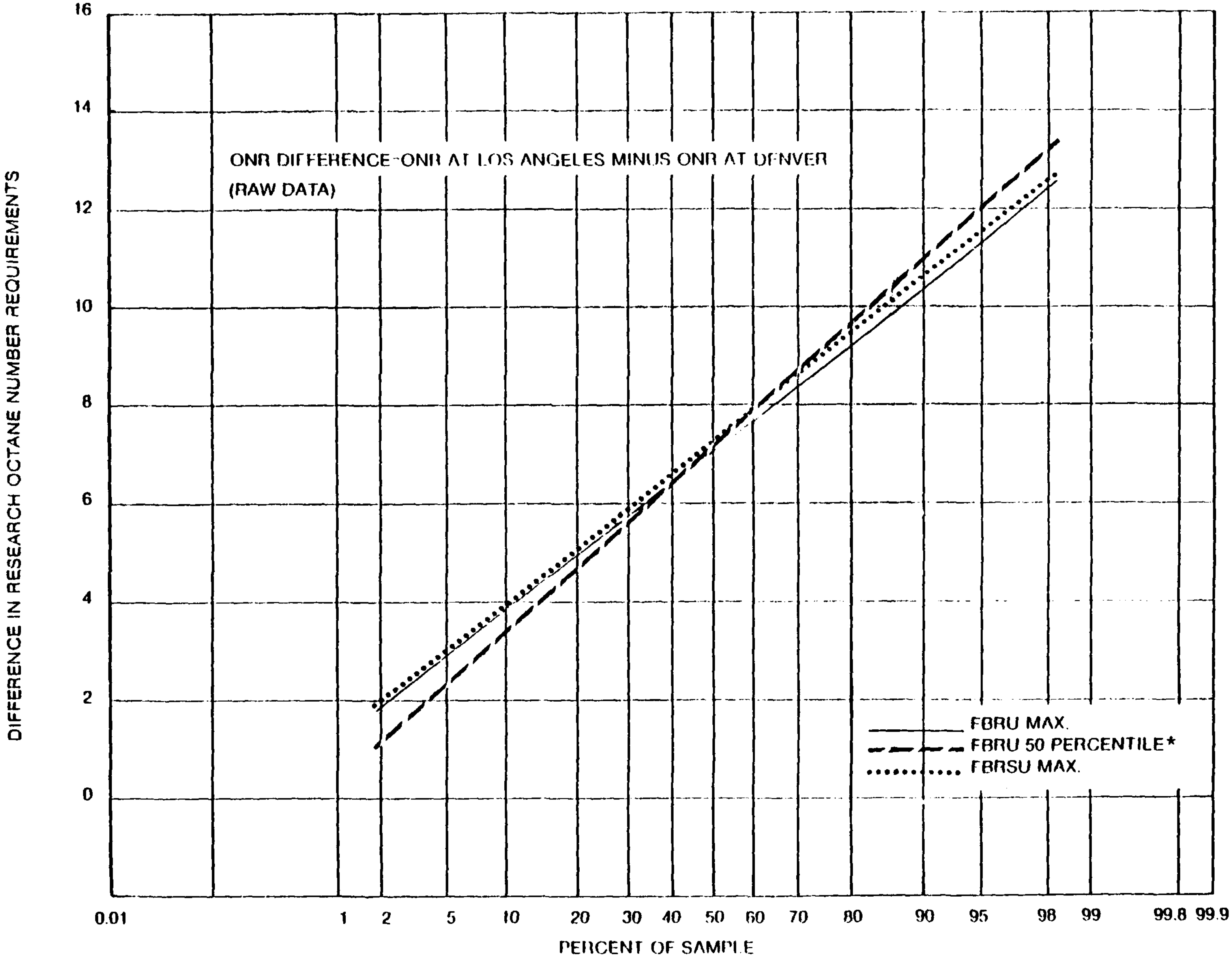
DISTRIBUTION OF DIFFERENCES IN OCTANE REQUIREMENTS--GROUP 6 CARS



* 50th Percentile Acceleration Technique

FIGURE 13

DISTRIBUTION OF DIFFERENCES IN OCTANE REQUIREMENTS-- GROUP 7 CARS



* 50th Percentile Acceleration Technique

A P P E N D I X   A

PARTICIPANTS

PARTICIPANTS

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Naperville, Illinois

Chevron Research Company
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Gulf Research and Development Company
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Marathon Research Center
Denver, Colorado

Mobil Research and Development Corporation
Paulsboro, New Jersey

Shell Development Company
Houston, Texas

Standard Oil Company (Ohio)
Cleveland, Ohio

Union Oil Company of California
Brea, California

EQUIPMENT AND FACILITIES

General Motors Emission Test Facility

-- Garage facilities and base of operation in Denver, Colorado

Union Oil Research Center

-- Garage facilities and base of operation in Brea, California

A P P E N D I X B

MEMBERSHIP: 1981 CRC ALTITUDE OCTANE REQUIREMENT PROGRAM ANALYSIS PANEL

1981 CRC ALTITUDE OCTANE REQUIREMENT PROGRAM

(CRC Project No. CM-124-81)

1981 ANALYSIS PANEL

J. D. Benson, Leader	General Motors Research Laboratories
P. W. Misangyi	Ford Motor Company
J. B. Smith	Amoco Research Center
T. Wusz	Union Oil Company of California

APPENDIX C

1981 CRC ALTITUDE OCTANE REQUIREMENT TESTING PROGRAM

COORDINATING RESEARCH COUNCIL
INCORPORATED
219 PERIMETER CENTER PARKWAY
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1981 CRC ALTITUDE OCTANE REQUIREMENT PROGRAM

CRC Project No. CM-124-81

Revised

January 1981

1981 CRC Altitude Octane Requirement Program

Objectives

The purpose of this work is to determine the effect of altitude on octane requirements of 1981 cars, particularly those with electronic control of air-fuel mixture and spark timing, and provide technical data for ASTM to consider for possible adjustment of the D-439 altitude octane specifications for gasoline.

Introduction

In 1977, CRC conducted an altitude octane program and found that octane requirements of vehicles (even those with altitude compensation) decreased substantially at high altitude compared to the requirements at sea level.

Many of the 1981 model cars will be equipped with electronic systems for controlling air-fuel ratio and spark timing, and the use of these systems may become more common in subsequent model years. In the past, octane requirements of engines have decreased with increasing altitude primarily because of three factors: carburetor enrichment, less vacuum spark advance (weaker vacuum signal), and reduced charge density with decreasing barometric pressure. Accordingly, gasolines sold in high altitude locations may have lower octane quality than those sold at sea level. However, with some of the 1981 cars, air-fuel mixtures at part-throttle are controlled near stoichiometric regardless of altitude, and spark timing may be advanced as barometric pressure decreases. Therefore, it is anticipated that octane requirements of these vehicles may not decrease as much with increasing altitude as has been observed with previous model cars.

This program is being proposed because both the oil companies and the automobile manufacturers are interested in satisfying the octane requirements of 1981 and future vehicles at high altitude locations as well as at sea level.

Test Location

High altitude tests would be conducted at Denver, Colorado, which has an elevation of 5280 feet. A public road, which was used for the 1977 program, would be used for running the vehicle tests, and General Motors Emissions Test Facility would be used as the base of operations.

The low altitude tests would be run in the Los Angeles, California, area (200 feet altitude), and Union Oil Company Research Laboratories would be used as the base of operations for this portion of the program.

Reference Fuels

Octane requirements at all altitudes will be measured using the FBRU and FBRSU series of 1981 CRC unleaded full-boiling range fuels. Each fuel series will cover a range

of approximately 77 to 102 Research octane numbers and will be crossblended from three base fuels. Fuels for this program will be obtained from the same batch as those used in the 1981 CRC Octane Number Requirement Survey. Primary reference fuels will not be tested in this program, nor will ratings be determined on each vehicle's tank fuel.

Design specifications for octane number, lead content, and hydrocarbon type for each of the full-boiling range base fuels are shown in Table 1.

Cars

Eight models of 1981 cars have been selected, and ten cars of each model, except the GM cars with the 4.1L V-6 engine, will be rented in the Denver area. General Motors will provide six cars with the 4.1L V-6 engine for this program since none could be found in Denver car rental fleets. All of the cars will have accumulated at least 6,000 miles and will be in good mechanical condition. The following models have been selected:

Make	Model	Engine Displ.-L	Type	Special Features
GM	Citation, Phoenix, Skylark, or Omega	2.5	L-4	CLAF, EST
GM	Citation, Phoenix, Skylark, or Omega	2.8	V-6	CLAF, EST
GM	Cutlass or Regal	3.8	V-6	CLAF, EST, BARO
GM	Electra, 98, or Cadillac	4.1	V-6	CLAF, EST, BARO
Ford	Mustang	2.3	L-4	CLAF
Ford	Lincoln	5.0	V-8	CLAF (F.I.), EST, BARO
Chrysler	Aries or Reliant	2.2	L-4	CLAF, EST
Toyota	Corolla	1.8	L-4	CLAF

*Abbreviations: CLAF = closed loop air-fuel control
EST = electronic spark timing
BARO = spark advanced with decreasing barometric pressure

Test Procedure

All tests will be conducted using the CRC E-15-81 test technique. Vehicle tests will be performed in the following sequence:

1. Determine octane number requirements of all 76 cars at Denver (5280 feet). Cars which have octane requirements less than the lowest reference fuel will be rejected from the program, and additional cars with definable requirements will be tested as replacements.

2. Transport all 76 cars to Los Angeles, and determine octane number requirements at 200 feet elevation.

It is anticipated that eight to ten cars will be tested each day, thus the time required for on-site testing will be approximately two weeks in Denver and two weeks in Los Angeles. This allows a few extra days for preparation, bad weather, and scheduling problems.

Participation and Timing

Approximately 16 people will be needed to staff this program during the entire four-week period of testing at both locations. Minimum personnel requirements will be as follows:

5 rating crews (2 men each) = 10 total

2 mechanics

2 coordinators and data-handlers

2 fuel-handlers

The test program will begin in Denver on June 1, 1981.

TABLE C-I

LIMITING SPECIFICATIONS FOR 1981 FULL-BOILING RANGE REFERENCE FUELS*

Inspection Tests	Unleaded Average Sensitivity Reference Fuels (FBRU)				Unleaded High Sensitivity Reference Fuel (FBRSU)		
	RMFD 332		RMFD 333	RMFD 334	RMFD 335	RMFD 336	RMFD 337
ASTM Distillation, °F(°C)							
IBP	90	(32.2)	90	90	90	90	90
10% Evap.	115-158	(46.1-70.0)	115-158	115-158	115-158	115-158	115-158
30% Evap.	150-190	(65.6-87.8)	150-190	150-190	150-190	150-190	150-190
50% Evap.	195-250	(90.6-121.1)	195-250	195-250	195-250	195-250	195-250
70% Evap.	230-300	(110.0-148.9)	230-300	230-300	230-300	230-300	230-300
90% Evap.	285-374	(140.6-190.0)	285-374	285-374	285-374	285-374	285-374
End Point, Max.	437	(225)	437	437	437	437	437
RVP, psi (KPa)	7-9	(48-62)	7-9	7-9	7-9	7-9	7-9
Lead, g/gal (g/l)	<0.03	(<0.008)	<0.03	<0.03	<0.03	<0.03	<0.03
Oxidation Stability, minutes, minimum	1440		1440	1440	1440	1440	1440
Hydrocarbon Type, Vol %	To be determined by inspection and reported						
Aromatics**							
Olefins							
Saturates							
Octane Number							
Research	77±1		90±1	101±1	77±1	90±1	101±1
Sensitivity***	4±.5		7.7±.5	11±.5	6.0±.5	9.7±.5	13±.5
Color	Clear		Green	Red	Yellow	Deep Purple	Light Blue

All fuels to contain minimum 5 PTB of a 100% active antioxidant. No manganese added.

* To be compounded from normal refinery components

** 1% maximum Benzene or legal

*** Sensitivites are shown for the mean Research Octane Number.

Minimum of two units sensitivity difference between corresponding fuels of each series.

Attachment 1

TECHNIQUE FOR DETERMINATION OF OCTANE NUMBER REQUIREMENTS OF LIGHT-DUTY VEHICLES

(CRC Designation E-15-81)

Revised

September 1980

TECHNIQUE FOR DETERMINATION OF OCTANE NUMBER REQUIREMENTS OF LIGHT-DUTY VEHICLES

(CRC Designation E-15-81)

A. GENERAL

The technique provides for the determination of octane number requirements of a vehicle in terms of borderline spark knock and surface ignition knock, regardless of throttle position, on two series of full-boiling range reference fuels as well as on primary reference fuels. It also provides octane requirements throughout the speed range on primary reference fuels.

Spark knock, surface ignition, and after-run characteristics of tank fuel will also be determined.

B. DEFINITION OF TERMS

1. The following definitions of knock were approved by the CFR and CLR Committees on June 8, 1954, and will be used in this technique. Knock is the noise associated with autoignition* of a portion of the fuel-air mixture ahead of the advancing flame front. The flame front is presupposed to be moving at normal velocity. With this definition, the source of the normal flame front is immaterial; it may be the result of surface ignition or spark ignition.

    a. Spark Knock: A knock which is recurrent and repeatable in terms of audibility. It is controllable by the spark advance; advancing the spark increases the knock intensity, and retarding the spark reduces the intensity. This definition does not include surface ignition knock.

    b. Surface Ignition Knock: Knock which has been preceded by a surface ignition. It is not controllable by spark advance.** It may or may not be recurrent and repeatable.

---

* Autoignition: The spontaneous ignition and the resulting very rapid reaction of a portion or all of the fuel-air mixture. The flame speed is many, many times greater than that which follows normal spark ignition. There is no time reference for autoignition.

** For the purpose of this program, it is not intended that surface ignition knock be identified by manipulation of the spark advance.

2. The following definitions of knock intensity were specifically adopted for use in this technique:

   a. No Knock: This means no spark knock or surface ignition knock.

   b. Borderline Knock: This means spark knock of lowest audible intensity, recurrent surface ignition knock of borderline intensity, or infrequent (three or less) surface ignition knocks regardless of intensity.

   c. Above Borderline Knock: This means greater than borderline spark knock, recurrent suface ignition knock greater than borderline intensity, or frequent (four or more) surface ignition knocks regardless of intensity.

   d. After-Run: The engine continues to operate after the ignition is turned off.

3. Definition of Accelerations

   Accelerations are made at maximum-throttle and part-throttle conditions which are defined below:

   a. Maximum-Throttle: The throttle is depressed and held at detent throughout the acceleration. This could be in highest gear or passing gear for automatic transmissions. The detent manifold vacuum obtainable on a given model is determined by the transmission characteristics.

   b. Part-Throttle: The throttle is depressed and regulated throughout the acceleration to maintain a desired, constant critical manifold vacuum in highest gear. Part-throttle will constitute any throttle position above detent vacuum up to the highest road load vacuum,

   c. 50th Percentile: The throttle is depressed and regulated to maintain an acceleration profile representative of average customer driving patterns.

C. VEHICLE PREPARATION

The following vehicle preparation steps should be completed before any octane tests are run. Detailed procedures for each adjustment can be found in the manufacturers' shop manuals.

1. Record vehicle identification number and emission control type, Federal, Altitude, or California. Fill in heading on data sheet DFMF-11-1181. Ford emission calibration numbers are to be recorded.

2. Inspect all vacuum lines and air pump hoses for appropriate connections. Also, check to see if PCV valve, distributor vacuum delay valve, EGR valve, and heated inlet air mechanism are functioning. Engine must be warmed up for these checks.

3. Record engine idle speed and observe anti-dieseling solenoid operation. Adjust to manufacturers' recommended specifications as specified on the under-hood decal.

4. Observe and record basic spark timing at recommended engine speed. Adjust to manufacturers' recommended setting as specified on the under-hood decal.

5. Crankcase oil, radiator coolant, automatic transmission fluid, and battery fluid levels shall be maintained as recommended by the manufacturer.

6. A calibrated tachometer graduated in 100 rpm (or smaller) increments and capable of indicating engine speed from 0-5000 rpm shall be installed on each vehicle.

7. One calibrated vacuum gage, graduated in one-half inch of mercury (or smaller) increments and capable of indicating vacuum from 0-24 inches of mercury (0-81 KPa) shall be connected to the intake manifold.

8. An auxiliary fuel system shall be provided to supply test fuels to the engine. Caution shall be taken to avoid placing auxiliary fuel lines in locations which promote vapor lock. If vehicles with carbureted engines have tank return fuel lines, this return line should be blocked off. Disconnect fuel tank vent line at evaporation control system canister. Instructions for fuel handling with fuel injection systems are given in Appendix A.

9. For vehicles equipped with knock sensor systems, instrumentation should be installed as described in Appendix B.

10. For vehicles with owner questionnaire completed, a sample of the tank gasoline shall be withdrawn for determination of Research and Motor method octane number ratings.

D. <u>TEST PROCEDURE</u>

1. <u>Engine Warm-Up</u>

   a. To stabilize engine temperatures, a minimum of ten miles of warm-up is required. The test vehicle should be operated at 55 mph (88 kph) in top gear with a minimum of full-throttle operation.

   b. During the warm-up period, the general mechanical condition of the vehicle should be checked to insure satisfactory and safe operation during test work.

2. Fuel Change-Over

Caution: Because of the installation of catalytic devices on these vehicles, permanent damage may result if the engine runs lean or stalls. Therefore, change-over from one fuel to another must be accomplished without running the carburetor or fuel injection system dry. Fuel handling procedures for vehicles equipped with fuel injection systems are explained in Appendix A.

To eliminate contamination of the new fuel with residual amounts of the previous fuel, flush system twice with new fuel.

After fuel change-over, make one maximum-throttle acceleration before beginning Vehicle Rating Procedure.

3. Details of Observations

a. Operating Conditions

All octane number requirements will be determined under level road acceleration conditions.

Manual Transmissions: Vehicles with 3- and 4-speed transmissions shall be rated in highest gear. Vehicles with 5-speed transmissions shall be rated in 4th gear.

Automatic Transmissions: Automatic transmissions shall be run in the highest gear possible.

Tests will be conducted on moderately dry days, preferably at ambient temperatures above 60°F (15.5° C). Tests should not be conducted during periods of high humidity such as prevail when rain is threatening or during or immediately after a rain storm. Laboratories with control capabilities should target for 70°F (21°C) air temperature and 50 grains of water per pound (7.14 gm/kg) of dry air whenever possible.

Air-conditioned vehicles will be tested with air conditioner turned ON. (Normal setting, low fan)

b. Order of Fuel Testing

1. Tank
2. FBRSU
3. FBRU
4. Primary

c. Determination of Knock Intensity

Octane requirements will be established by evaluating the occurrence of knock in terms of knock intensity:

"N" for none, "B" for borderline, and "A" for above borderline. Establishment of representative knock intensity for a given fuel will be accomplished with the fewest number of accelerations possible. As defined below, the first two duplicating accelerations are sufficient with "N" and "B" knock intensity.

Number of Accelerations			Representative Rating
1	2	3	
N	N	-	N
N	B	N	N
N	B	B	B
B	N	B	B
B	B	-	B
B	A	-	A
A	-	-	A

All subsequent accelerations will normally be discontinued when "A" knock intensity is experienced, and testing continued with a higher octane number fuel in that series. An exception will be made if "A" knock is experienced on the highest octane fuel which knocks in the engine. In this case, it may be necessary to run additional accelerations to determine the speed of maximum knock intensity. If "A" knock is experienced at initiation of acceleration, as limited by transmission characteristics, this speed will be considered the speed of maximum knock. Otherwise, the midpoint between knock-in and knock-out will be considered the speed of maximum knock. When establishing knock-in and knock-out, back off on the throttle between points to eliminate "A" knock. Tip-in knock should be ignored.

d. Determination of Octane Requirements and After-Run Characteristics

Tests should be run to 60 mph (97 kph) unless required to terminate at 55 mph (88 kph) because of legal speed limits.

The procedure for knock sensor equipped-cars is shown in Appendix B.

1) Vehicle Operating Procedure (for driver)

a) For establishment of transmission characteristics, obtain top gear downshift engine rpm and manifold vacuum at 25, 35, 45, and 55 mph (40, 56, 72, 88 kph) by movement of the throttle through the detent position. Record both engine rpm and manifold vacuum at the downshift point for each speed.

The vehicle brakes may be applied lightly, if necessary, to maintain vehicle speed. In addition, for transmissions with converter clutches, determine the minimum vacuum and minimum road speed for converter clutch application. Record on data sheet.

b) For maximum-throttle requirements in highest gear, accelerate at the detent position from the minimum obtainable speed as determined in (a)* up to 60 mph (97 mph). If transmission downshifts, abort and start acceleration again.

c) For maximum-throttle requirements in passing gear for vehicles with automatic transmissions, accelerate from 10 mph (16 kph) below the starting speed for highest gear acceleration up to 60 mph (97 kph). When available, set shift gear selector to passing gear.

d) For those vehicles with vacuum delay devices, to stabilize vacuum advance before starting each part-throttle acceleration, operate at road load for 40 seconds at the speed from which the acceleration is to begin.

e) For part-throttle requirements, accelerate in highest gear at constant critical manifold vacuum from minimum obtainable speed to 60 mph (97 kph), or until vehicle ceases to accelerate. To obtain critical part-throttle vacuum, operate at road load for 40 seconds at 25, 35, 45, and 55 mph (40, 56, 72, and 88 kph). At each speed, move the throttle (in 3 to 5 seconds) from the highest road load vacuum down to detent manifold vacuum, or 1 inch Hg (3.4 KPa) above the minimum vacuum at which converter clutch engages. In this range, find a manifold vacuum for maximum knock intensity to use as the critical vacuum for all subsequent part-throttle accelerations. The vehicle brakes may be applied lightly, if necessary, to maintain vehicle speed, except for vehicles with converter clutch transmissions.

---

* Starting speed for accelerations on manual transmission vehicles should be the lowest speed from which the vehicle will accelerate smoothly.

f) For <u>50th percentile requirements</u>, follow the driving cycle described in Modes 1 and 2 below:

<u>Mode 1</u>: Idle 20 seconds. Make a 50th percentile acceleration through the gears to 60 mph. Decelerate to 55 mph and cruise for 0.5 mile. Decelerate moderately to 30 mph.

<u>Mode 2</u>: Cruise at 30 mph for 0.2 mile. Make a 50th percentile acceleration to 60 mph. Decelerate to 55 mph and cruise for 0.5 mile. Decelerate moderately to a stop.

Run the number of cycles necessary to be consistent with the table on page 15. Complete cycles (both modes) should be performed regardless of the mode in which knock occurs.

The 50th percentile acceleration profile is shown in Appendix C.

g) <u>Determination of After-Run Characteristics</u>

Determination of the occurrence of after-run will be evaluated on tank fuel. Following the engine warm-up, moderately brake the vehicle to a stop (foot off throttle) and place automatic transmission vehicles in park position, manual transmission vehicles in neutral. <u>Air conditioner must be turned off</u>. Immediately turn key to the "OFF" position. Note on the data sheet if after-run occurs.

2) <u>Vehicle Rating Procedure (for rater)</u>

Knock rating should be performed while in a normal seated position (head above instrument panel) with floor mats in place.

Step 1 - Using a fuel estimated to give borderline knock in a given fuel series, investigate for incidence of knock under conditions as described in 3d(1)(b) above, and 3d(1)(c) above.

Step 2 - If no knock occurs, go to a lower octane number blend in that series and repeat Step 1.

Step 3 - If knock occurs at one or more of the operating conditions in Step 1, continue investigation at the critical condition(s) with higher octane blends until highest octane fuel giving knock is determined within one octane number or one blend. Record maximum knock intensity on all fuels and speed of maximum knock intensity on highest octane fuel that knocks.

Step 4 - Using the lowest octane blend that did not knock in Step 3, investigate for incidence of part-throttle knock as described in 3d (1)(e). If knock occurs, continue investigation at critical vacuum until requirement is defined. Record maximum knock intensity and critical manifold vacuum on all fuels, and speed of maximum knock intensity on highest octane fuel that knocks.

Step 5 - With FBRU fuel only, investigate for incidence of knock with 50th percentile accelerations as described in 3d(1)(f). If knock occurs, continue investigation using both modes with higher octane blends until highest octane fuel giving knock is determined within one octane number or one blend. If no knock occurs, investigate for knock with lower octane number fuels until the requirement is determined or the lowest octane number fuel has been used. Record maximum knock intensity on all fuels, and mode, manifold vacuum, and speed of maximum knock intensity on highest octane fuel that knocks.

The rating procedure is given in arrow diagram form on page 21.

e. Tank Fuel Observations on Vehicles with Owner's Questionnaire

Investigate for maximum-throttle and part-throttle knock as detailed in Item 3d(1). Define maximum knock intensity as per Item 3c. Record maximum knock intensity, speed of maximum knock intensity, and manifold vacuum at each operating condition. Determine after-run characteristics as described in Item 3d(1)(g).

f. Octane Number Requirement Over Speed Range

Octane requirements over the speed range will be obtained on primary reference fuels only using throttle position

for maximum requirements. These will be established by recording the knock-in and knock-out points during maximum requirement acceleration with each incremental fuel investigated. It may be necessary to test one or two additional lower octane fuels to describe the knocking characteristics over the speed range. Accelerate at maximum-throttle from minimum obtainable speed as determined in 3d(1)(a), up to 3500 rpm, if necessary, in order to define requirements. These should be run to 60 mph (97 kph) unless required to terminate at 55 mph (88 kph) because of legal speed limits. If 3500 rpm cannot be attained in top gear, accelerations shall be discontinued and resumed in the next highest gear from 500 rpm below the engine speed at which top gear accelerations were determined.

When "A" knock is experienced, continue the acceleration, but back off on the throttle to maintain "B" knock until just prior to the knock-out point.

E. INTERPRETATION OF DATA

The data will be recorded on data sheet DFMF-11-1181. Octane requirements for all reference fuels shall be determined as follows:

1. If the knock intensity of the highest fuel giving knock is borderline, the requirement shall be reported as the octane number of that fuel.

2. If the knock intensity of the highest fuel giving knock is above borderline, the requirement shall be reported as one-half the difference between the fuel giving knock and the next highest fuel.

Speed range data shall be reported on data sheet DFMF-11-1181 as the engine speed of knock-in and knock-out for the octane number of the primary reference fuel tested.

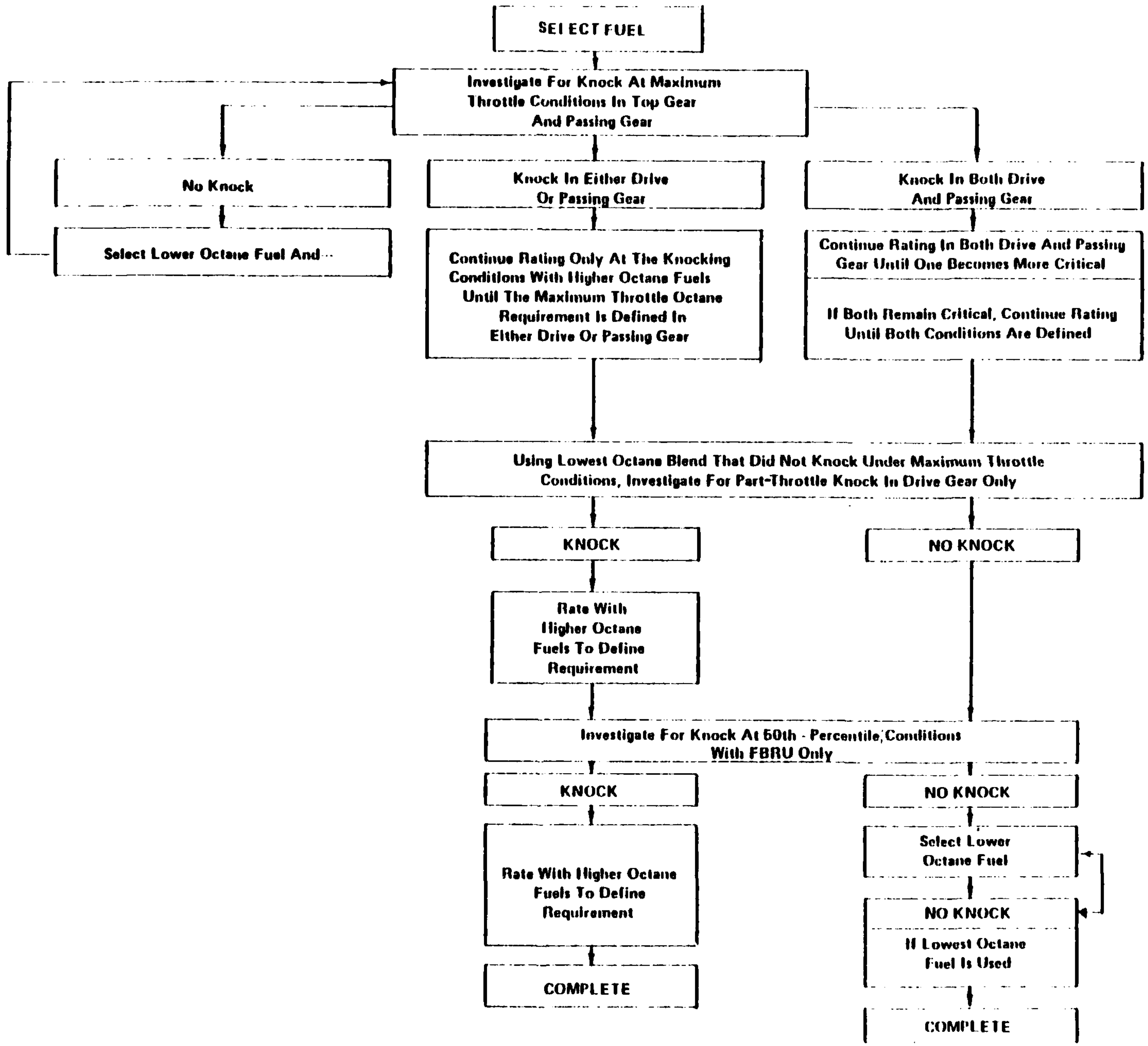
When transferring data to the summary report form, record "no" data as well as "yes" data.

Record data on all fuels tested, even though knock was not encountered. When transferring data to the summary report form DFMF-15-1181, record the higher among requirements under part-throttle and maximum-throttle condition for all fuels, and the 50th percentile requirement for FBRU fuel. Use proper letter designation (see footnotes on summary sheet) to designate requirements outside of the reference fuel limits.

Requirements for the various engine speeds will be determined by fitting a smooth curve through the knock-in and knock-out points

on work form DFMF-12-1181. Primary reference fuel requirements at various engine speeds should be reported to the nearest one-half octane number and recorded on the speed range summary sheets DFMF-25-1181.

It is important that the vehicle identification number (VIN) of each vehicle tested be recorded on all data and summary sheets to provide a means of cross-indexing.

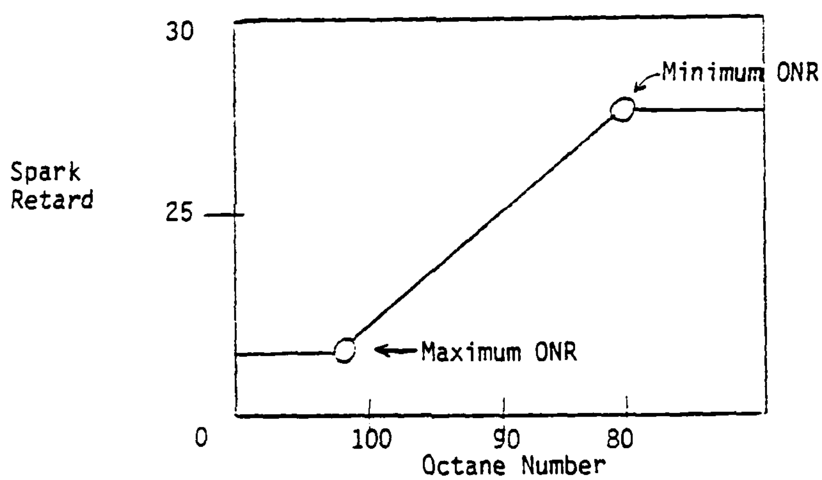

SELECT FUEL
Investigate For Knock At Maximum Throttle Conditions In Top Gear And Passing Gear
No Knock
Select Lower Octane Fuel And···
Knock In Either Drive Or Passing Gear
Continue Rating Only At The Knocking Conditions With Higher Octane Fuels Until The Maximum Throttle Octane Requirement Is Defined In Either Drive Or Passing Gear
Knock In Both Drive And Passing Gear
Continue Rating In Both Drive And Passing Gear Until One Becomes More Critical
If Both Remain Critical, Continue Rating Until Both Conditions Are Defined
Using Lowest Octane Blend That Did Not Knock Under Maximum Throttle Conditions, Investigate For Part-Throttle Knock In Drive Gear Only
KNOCK
NO KNOCK
Rate With Higher Octane Fuels To Define Requirement
Investigate For Knock At 50th - Percentile Conditions With FBRU Only
KNOCK
NO KNOCK
Rate With Higher Octane Fuels To Define Requirement
Select Lower Octane Fuel
NO KNOCK
If Lowest Octane Fuel Is Used
COMPLETE
COMPLETE

Attachment 2

ONR MEASUREMENT WITH KNOCK SENSOR
EQUIPPED VEHICLES - INSTRUMENT METHOD

The test method will define the limits of the vehicles ability to adapt to varying fuel quality. This will be accomplished by observing the knock sensor output as a function of spark retard. Also, the fuel quality for borderline knock will be determined.

Prepare the vehicle according to Section C (Vehicle Preparation) and, in addition, install a spark retard indicator. Using an estimated non-knocking fuel, accelerate as defined in B-3 and observe spark retard. Using lower octane fuels, continue testing until the maximum octane requirement and minimum octane requirement have been determined. The maximum requirement is the fuel quality at which spark retard begins. The minimum requirement is the fuel quality at which the spark retard reaches a maximum. (See Figure)



Record knock intensity on all fuels for maximum and minimum octane in accordance with B-2. Also, determine the octane number of the fuel that gives borderline knock using the accelerations defined in B-3. Record the degrees of spark retard associated with the borderline knock.

Data should be recorded on data form DFMF-26-1181 and plotted on curve sheet DFMF-27-1181.

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A P P E N D I X   D

DATA ON 1981 FULL-BOILING RANGE REFERENCE FUELS

TABLE D-I

OCTANE NUMBERS AND COMPOSITIONS FOR 1981 FBRU FUELS

	Volume Percent					
RON	RMFD 332-81	RMFD 333-81	RMFD 334-81	MON	SEN	(R+M)/2
78	97.0	3.0	-	74.3	3.7	76.2
80	82.5	17.5	-	76.1	3.9	78.1
82	67.0	33.0	-	77.8	4.2	79.9
84	52.0	48.0	-	79.2	4.8	81.6
85	44.0	56.0	-	79.8	5.2	82.4
86	36.0	64.0	-	80.4	5.6	83.2
87	28.0	72.0	-	81.0	6.0	84.0
88	20.0	80.0	-	81.6	6.4	84.8
89	12.0	88.0	-	82.1	6.9	85.6
90	4.0	96.0	-	82.7	7.3	86.4
91	-	95.0	5.0	83.2	7.8	87.1
92	-	85.0	15.0	83.7	8.3	87.9
93	-	75.0	25.0	84.3	8.7	88.7
94	-	65.0	35.0	84.9	9.1	89.5
95	-	55.0	45.0	85.5	9.5	90.3
96	-	45.0	55.0	86.0	10.0	91.0
97	-	34.0	66.0	86.7	10.3	91.9
98	-	24.0	76.0	87.4	10.6	92.7
99	-	15.0	85.0	88.1	10.9	93.6
100	-	3.0	97.0	88.8	11.2	94.4

TABLE D-II

OCTANE NUMBERS AND COMPOSITIONS FOR 1981 FBRSU FUELS

	Volume Percent					
RON	RMFD 335-81	RMFD 336-81	RMFD 337-81	MON	SEN	(R+M)/2
78	96.0	4.0	-	72.2	5.8	75.1
80	81.0	19.0	-	73.6	6.4	76.8
82	66.0	34.0	-	75.1	6.9	78.6
84	51.0	49.0	-	76.5	7.5	80.3
85	43.0	57.0	-	77.3	7.7	81.2
86	35.5	64.5	-	78.0	8.0	82.0
87	27.5	72.5	-	78.7	8.3	82.9
88	20.0	80.0	-	79.4	8.6	83.7
89	12.0	88.0	-	80.1	8.9	84.6
90	4.0	96.0	-	80.8	9.2	85.4
91	-	96.0	4.0	81.4	9.6	86.2
92	-	87.5	12.5	82.1	9.9	87.1
93	-	79.0	21.0	82.8	10.2	87.9
94	-	70.0	30.0	83.4	10.6	88.7
95	-	61.0	39.0	84.1	10.9	89.6
96	-	52.0	48.0	84.8	11.2	90.4
97	-	42.5	57.5	85.5	11.5	91.3
98	-	33.0	67.0	86.2	11.8	92.1
99	-	22.5	77.5	86.9	12.1	93.0
100	-	10.0	90.0	87.6	12.4	93.8
101	-	-	100.0	88.3	12.7	94.7

TABLE D-III

INSPECTION DATA ON 1981 RMFD FUELS

Property	Value for RMFD Fuel 332	333	334	335	336	337
ASTM Distillation						
IBP (°F)	97	97	91	101	99	103
10%	130	126	124	134	134	131
30%	160	167	173	174	170	179
50%	197	204	225	217	202	232
70%	235	232	247	266	237	268
90%	308	285	285	354	320	315
EP	383	377	347	412	406	390
API Gravity	66.9	62.2	53.1	62.8	58.1	53.5
RVP (psi)	8.4	9.0	9.0	7.3	7.6	8.2
Pb (g/gal)	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Oxidation Stability (min)	>1440	>1440	>1440	>1440	>1440	>1440
Hydrocarbon Composition (Volume %)						
Saturates (P+N)	77	74	53	51	65	52
Olefins	5	8	0	33	10	5
Aromatics	18	18	47	16	25	43
Research O.N.	77.4	90.7	100.4	77.8	90.7	101.5
Motor O.N.	73.6	82.9	89.1	71.4	80.8	88.4
Sensitivity	3.8	7.8	11.3	6.4	9.9	13.1

TABLE D-IV

COMPOSITION DATA ON 1981 RMFD FUELS

Component	Volume % in RMFD Fuel					
	332	333	334	335	336	337
Mixed Xylenes	5.5	---	7.4	---	---	14.4
Nonyl Aromatics	---	2.2	7.4	---	3.9	14.3
Heavy Platformate	---	8.4	34.6	---	8.7	12.2
Cyclopentane	---	4.8	6.7	---	7.8	9.4
ASTM Isooctane	2.7	---	14.8	---	---	19.8
Soltrol 10	9.1	11.7	---	---	9.7	---
n-Butane	3.4	5.6	5.0	2.5	3.9	4.4
iso-Pentane	---	8.1	15.7	---	4.9	13.3
Cat Cracked Gasoline	10.9	---	---	74.9	---	12.2
Housebrand Gasoline Base Blend	---	28.5	---	---	36.9	---
Soltrol 50	---	11.7	---	---	---	---
Cyclohexane	---	12.1	---	---	13.6	---
Refinery Platformate	27.7	2.1	---	---	7.8	---
iso-Hexanes	13.4	---	---	---	---	---
n-Pentane	13.7	2.5	8.4	8.6	---	---
n-Hexane	4.0	2.3	---	---	---	---
ASTM n-Heptane	9.6	---	---	14.2	2.8	---

APPENDIX E

WEATHER CONDITIONS FOR THE 1981 ALTITUDE OCTANE REQUIREMENT PROGRAM

TABLE E-I

BAROMETRIC PRESSURE, In. Hg

Group No.	High		Low		Mean	
	LA	Denver	LA	Denver	LA	Denver
1	29.70	24.78	29.64	24.63	29.67	24.71
2	29.72	24.80	29.42	24.53	29.57	24.66
3	29.70	24.80	29.59	24.73	29.64	24.76
4	29.70	24.80	29.61	24.53	29.66	24.67
5	29.71	24.80	29.59	24.60	29.65	24.70
6	29.73	24.70	29.61	24.55	29.67	24.62
7	29.73	24.78	29.60	24.53	29.67	24.66
8	29.71	24.68	29.67	24.55	29.69	24.62
All Groups	29.73	24.80	29.42	24.53	29.65	24.68

TABLE E-II

ABSOLUTE HUMIDITY

(Grains H_2O/lb Dry Air)

Group No.	High		Low		Mean	
	LA	Denver	LA	Denver	LA	Denver
1	82	96	56	52	69	74
2	92	91	50	59	71	75
3	85	82	26	66	56	74
4	85	96	26	59	56	78
5	86	96	36	65	61	81
6	85	84	70	68	78	76
7	85	89	66	59	76	74
8	92	83	64	60	78	72
All Groups	92	96	26	52	68	76

TABLE E-III

AMBIENT TEMPERATURE, °F

Group No.	High		Low		Mean	
	LA	Denver	LA	Denver	LA	Denver
1	104	79	68	72	86	76
2	104	95	77	76	91	86
3	110	84	80	68	95	76
4	107	95	77	73	92	84
5	110	83	75	68	92	76
6	93	87	80	69	86	78
7	93	95	72	69	82	82
8	95	91	73	69	84	80
All Groups	110	95	68	68	88	80

A P P E N D I X   F

INDIVIDUAL CAR DATA

1981 CRC ALTITUDE PROGRAM - 1981 VEHICLES (RAW DATA - LOS ANGELES GROUP I)

VEHICLE									WEATHER			FBRU MAX REQUIREMENTS					FBRU 50 PERCENTILE *				FBRSU MAX REQUIREMENTS				
CYLS	OBS	CODE	EMIS	BBL	SEN	DISP	COMP	MILES	TEMP	BAROM	GR/LB	T	OCTANE	N	G	VAC	OCTANE	MPH	VAC	M	T	OCTANE	N	G	VAC
V-6	10L	IC7	F	2	N	2.8	8.5	8746	104.	29.67	56.	M	87.5	K	P	1.0	87.5	40.	1.0	1	M	87.5	K	D	1.0
V-6	11L	LC7	F	2	N	2.8	8.5	8680	68.	29.64	57.	P	88.0	K	D	8.0	88.0	28.	7.5	1	P	91.0	K	D	8.0
V-6	12L	LC7	F	2	N	2.8	8.5	11431	85.	29.65	60.	M	92.0	K	P	2.0	92.0	20.	11.0	1	M	93.0	K	D	2.0
V-6	13L	LC7	F	2	N	2.8	8.5	11300	90.	29.64	62.	M	86.0	K	P	0.5	84.0	35.	3.0	1	M	87.0	K	P	0.5
V-6	14L	IC7	F	2	N	2.8	8.5	7380	74.	29.70	82.	M	86.0	K	D	0.5	84.0	51.	1.0	2	M	87.0	K	D	0.5
V-6	15L	IC7	F	2	N	2.8	8.5	7855	85.	29.65	60.	M	87.0	K	P	0.0	85.0	48.	1.0	1	M	87.5	K	P	0.0
V-6	16L	LC7	F	2	N	2.8	8.5	10444	88.	29.68	66.	M	90.0	K	P	2.0	90.0	35.	6.0	2	M	91.0	K	D	2.0
V-6	17L	IC7	F	2	N	2.8	8.5	8100	94.	29.69	60.	M	95.0	K	D	2.0	96.0	40.	5.0	1	M	96.0	K	D	2.0
V-6	18L	IC7	F	2	N	2.8	8.5	6336	93.	29.68	58.	M	90.0	K	P	0.0	90.5	45.	1.0	1	M	92.0	K	D	0.0
V-6	19L	IC7	F	2	N	2.8	8.5	7940	90.	29.65	62.	M	85.0	K	D	1.5	85.0	45.	4.5	1	M	87.0	K	D	1.5

(RAW DATA - DENVER GROUP I)

VEHICLE									WEATHER			FBRU MAX REQUIREMENTS					FBRU 50 PERCENTILE *				FBRSU MAX REQUIREMENTS				
CYLS	OBS	CODE	EMIS	BBL	SEN	DISP	COMP	MILES	TEMP	BAROM	GR/LB	T	OCTANE	N	G	VAC	OCTANE	MPH	VAC	M	T	OCTANE	N	G	VAC
V-6	10D	IC7	F	2	N	2.8	8.5	8650	78.	24.66	55.	M	83.0	K	P	2.0	78.0	50.	2.0	1	M	83.0	K	P	2.0
V-6	11D	LC7	F	2	N	2.8	8.5	8575	78.	24.66	55.	M	81.0	K	P	2.0	80.0	45.	2.0	1	M	82.0	K	P	2.0
V-6	12D	LC7	F	2	N	2.8	8.5	11353	79.	24.78	90.	M	85.0	K	D	2.0	85.0	30.	3.0	3	M	85.0	K	D	2.0
V-6	13D	LC7	F	2	N	2.8	8.5	11217	76.	24.66	53.	M	80.0	K	D	3.0	78.0	45.	3.0	1	M	82.0	K	D	0.0
V-6	14D	IC7	F	2	N	2.8	8.5	7311	72.	24.66	63.	M	80.0	K	P	0.0	78.0	55.	0.0	3	M	81.0	K	D	0.0
V-6	15D	IC7	F	2	N	2.8	8.5	7717	75.	24.63	96.	M	83.0	K	P	2.0	79.0	35.	3.0	2	M	84.0	K	P	2.0
V-6	16D	LC7	F	2	N	2.8	8.5	10313	76.	24.66	52.	M	80.0	K	D	1.5	78.0	36.	5.5	3	M	80.0	K	D	1.5
V-6	17D	IC7	F	2	N	2.8	8.5	7993	78.	24.66	91.	P	82.0	K	D	4.0	84.0	40.	1.0	2	P	84.0	K	D	4.0
V-6	18D	IC7	F	2	N	2.8	8.5	6214	76.	24.66	54.	M	81.0	K	D	2.0	79.0	32.	3.0	2	M	83.0	K	D	1.0
V-6	19D	IC7	F	2	N	2.8	8.5	7846	74.	24.66	81.	M	80.0	K	P	2.0	78.0	40.	4.0	3	M	82.0	K	P	2.0

NOTE: G = GEAR. M = MODE. N = NOISE. T = THROTTLE POS.

* 50th Percentile Acceleration Technique

1981 CRC ALTITUDE PROGRAM - 1981 VEHICLES (RAW DATA - LOS ANGELES GROUP 2)

VEHICLE									WEATHER			FBRU MAX REQUIREMENTS					FBRU 50 PERCENTILE*				FBRSU MAX REQUIREMENTS				
CYLS	OBS	CODE	EMIS	BBL	SEN	DISP	COMP	MILES	TEMP	BAROM	GR/LB	T	OCTANE	N	G	VAC	OCTANE	MPH	VAC	M	T	OCTANE	N	G	VAC
V-6	20L	IIA	A	2	N	3.8	8.0	11852	77.	29.42	72.	M	90.0	K	D	2.0	90.0	47.	2.0	1	M	92.0	K	D	2.0
V-6	21L	IIA	A	2	N	3.8	8.0	11730	94.	29.62	67.	M	91.0	K	D	2.0	89.0	50.	2.0	2	M	93.0	K	D	2.0
V-6	22L	IIA	A	2	N	3.8	8.0	12088	89.	29.71	72.	M	94.0	K	D	2.0	92.0	50.	2.0	1	M	95.0	K	D	2.0
V-6	23L	LIA	A	2	N	3.8	8.0	10365	80.	29.72	77.	M	88.0	K	D	1.0	88.0	35.	1.5	1	M	90.0	K	D	1.0
V-6	24L	IIA	A	2	N	3.8	8.0	15205	94.	29.69	60.	M	91.0	K	P	1.5	91.0	50.	2.0	1	M	92.0	K	P	1.5
V-6	25L	IIA	A	2	N	3.8	8.0	11942	85.	29.63	50.	M	90.0	K	D	2.0	89.0	45.	2.0	1	M	92.0	K	D	2.0
V-6	26L	LIA	A	2	N	3.8	8.0	11430	91.	29.68	82.	M	90.0	K	D	2.0	90.0	48.	2.0	3	M	91.0	K	D	2.0
V-6	27L	IIA	A	2	N	3.8	8.0	14770	78.	29.67	76.	M	88.0	K	D	2.0	87.0	45.	2.0	2	M	89.0	K	D	2.0
V-6	28L	LIA	A	2	N	3.8	8.0	10305	84.	29.66	92.	M	91.0	K	D	2.0	91.0	50.	2.0	2	M	93.0	K	D	2.0
V-6	29L	LIA	A	2	N	3.8	8.0	14051	104.	29.61	56.	M	93.0	K	D	2.0	93.0	54.	2.0	1	P	97.0	K	D	5.5

(RAW DATA - DENVER GROUP 2)

VEHICLE									WEATHER			FBRU MAX REQUIREMENTS					FBRU 50 PERCENTILE*				FBRSU MAX REQUIREMENTS				
CYLS	OBS	CODE	EMIS	BBL	SEN	DISP	COMP	MILES	TEMP	BAROM	GR/LB	T	OCTANE	N	G	VAC	OCTANE	MPH	VAC	M	T	OCTANE	N	G	VAC
V-6	20D	IIA	A	2	N	3.8	8.0	11750	76.	24.70	68.	M	87.0	K	D	0.0	88.0	35.	2.5	1	M	90.0	K	D	2.0
V-6	21D	IIA	A	2	N	3.8	8.0	11638	80.	24.70	82.	M	85.0	K	D	2.0	85.0	45.	2.5	1	M	87.0	K	D	2.0
V-6	22D	IIA	F	2	N	3.8	8.0	11997	79.	24.78	89.	M	88.0	K	P	2.0	88.0	35.	2.0	2	M	90.0	K	P	2.0
V-6	23D	LIA	A	2	N	3.8	8.0	10280	78.	24.80	91.	M	87.0	K	D	2.0	84.0	45.	2.0	1	M	88.0	K	D	2.0
V-6	24D	IIA	A	2	N	3.8	8.0	15123	95.	24.56	80.	M	88.0	K	D	2.0	88.0	50.	2.0	1	M	90.0	K	D	2.0
V-6	25D	IIA	A	2	N	3.8	8.0	11880	80.	24.76	82.	M	88.0	K	D	0.0	88.0	33.	2.0	1	M	89.0	K	D	0.0
V-6	26D	LIA	A	2	N	3.8	8.0	11337	91.	24.57	59.	M	86.0	K	D	2.0	86.0	45.	2.0	1	M	88.0	K	D	2.0
V-6	27D	IIA	A	2	N	3.8	8.0	14673	82.	24.53	63.	M	86.0	K	D	2.0	85.0	45.	2.0	1	M	88.0	K	D	2.0
V-6	28D	LIA	A	2	N	3.8	8.0	10147	91.	24.57	59.	M	89.0	K	D	3.0	87.0	45.	2.0	1	M	89.5	K	D	2.0
V-6	29D	LIA	A	2	N	3.8	8.0	13950	80.	24.78	82.	M	91.5	K	P	2.0	91.0	45.	2.5	1	M	92.0	K	D	2.0

NOTE: G = GEAR. M = MODE. N = NOISE. T = THROTTLE POS.

* 50th Percentile Acceleration Technique

1981 CRC ALTITUDE PROGRAM - 1981 VEHICLES (RAW DATA - LOS ANGELES GROUP 3)

VEHICLE									WEATHER			FBRU MAX REQUIREMENTS					FBRU 50 PERCENTILE *				FBRSU MAX REQUIREMENTS				
CYLS	OBS	CODE	EMIS	BBL	SEN	DISP	COMP	MILES	TEMP	BAROM	GR/LB	T	OCTANE	N	G	VAC	OCTANE	MPH	VAC	M	T	OCTANE	N	G	VAC
4	30L	T	F	2	N	1.8	9.0	6137	86.	29.64	74.	M	87.0	K	D	0.0	85.0	34.	0.0	2	M	87.0	K	P	0.0
4	31L	T	F	2	N	1.8	9.0	7510	107.	29.68	26.	M	89.0	K	D	2.0	89.0	19.	3.5	1	M	91.0	K	D	2.0
4	32L	T	F	2	N	1.8	9.0	6241	97.	29.63	62.	M	86.0	K	P	0.0	85.0	25.	0.0	1	M	89.0	K	P	0.0
4	33L	T	F	2	N	1.8	9.0	7053	95.	29.64	57.	M	88.0	K	D	2.5	89.0	40.	4.0	1	M	90.0	K	P	2.5
4	34L	T	F	2	N	1.8	9.0	6335	85.	29.63	50.	M	89.0	K	D	2.0	88.0	30.	2.5	2	M	90.0	K	P	2.0
4	35L	T	F	2	N	1.8	9.0	6415	92.	29.65	36.	M	89.0	K	D	2.5	88.0	35.	3.0	1	M	90.0	K	P	2.5
4	36L	T	F	2	N	1.8	9.0	6218	110.	29.59	46.	M	90.0	K	D	2.0	90.0	30.	2.0	1	M	92.0	K	D	2.0
4	37L	T	F	2	N	1.8	9.0	7845	107.	29.68	26.	M	89.0	K	D	2.0	88.0	45.	2.0	1	M	88.0	K	D	2.0
4	38L	T	F	2	N	1.8	9.0	6960	98.	29.61	83.	M	88.0	K	D	2.0	88.5	25.	3.0	1	M	89.0	K	D	2.0
4	39L	T	F	2	N	1.8	9.0	6898	80.	29.70	85.	M	94.0	K	D	2.5	94.0	30.	4.0	1	M	95.0	K	D	2.5

(RAW DATA - DENVER GROUP 3)

VEHICLE									WEATHER			FBRU MAX REQUIREMENTS					FBRU 50 PERCENTILE *				FBRSU MAX REQUIREMENTS				
CYLS	OBS	CODE	EMIS	BBL	SEN	DISP	COMP	MILES	TEMP	BAROM	GR/LB	T	OCTANE	N	G	VAC	OCTANE	MPH	VAC	M	T	OCTANE	N	G	VAC
4	30D	T	F	2	N	1.8	9.0	6033	84.	24.73	76.	M	79.0	K	P	2.0	78.0	28.	2.0	1	M	81.0	K	D	2.0
4	31D	T	F	2	N	1.8	9.0	7388	77.	24.76	71.	M	80.0	K	D	0.0	78.0	35.	1.0	1	M	81.0	K	D	0.0
4	32D	T	F	2	N	1.8	9.0	6103	77.	24.76	82.	M	79.0	K	D	1.5	79.0	22.	2.0	1	M	81.0	K	D	1.5
4	33D	T	F	2	N	1.8	9.0	6962	77.	24.76	82.	M	80.0	K	P	2.0	80.0	25.	3.0	1	M	82.0	K	P	2.0
4	34D	T	F	2	N	1.8	9.0	6274	77.	24.76	82.	M	80.0	K	D	2.0	80.0	30.	2.0	1	M	82.0	K	P	2.0
4	35D	T	F	2	N	1.8	9.0	6346	68.	24.76	66.	M	80.0	K	P	2.0	80.0	25.	2.0	1	M	82.0	K	P	2.0
4	36D	T	F	2	N	1.8	9.0	6156	68.	24.76	66.	M	80.0	K	D	1.0	78.0	12.	3.0	3	M	80.0	K	D	1.0
4	37D	T	F	2	N	1.8	9.0	7715	84.	24.73	76.	M	80.0	K	P	2.0	80.0	25.	2.0	1	M	81.0	K	D	2.0
4	38D	T	F	2	N	1.8	9.0	6894	77.	24.73	82.	M	80.0	K	D	2.0	80.0	28.	2.0	1	M	84.0	K	D	2.0
4	39D	T	F	2	N	1.8	9.0	8625	74.	24.80	76.	M	84.0	K	D	2.0	84.0	20.	2.0	3	M	86.0	K	D	2.0

NOTE: G - GEAR. M - MODE. N - NOISE. T - THROTTLE POS.

* 50th Percentile Acceleration Technique

1981 CRC ALTITUDE PROGRAM - 1981 VEHICLES (RAW DATA - LOS ANGELES GROUP 4)

VEHICLE									WEATHER			FBRU MAX REQUIREMENTS					FBRU 50 PERCENTILE *				FBRSU MAX REQUIREMENTS				
CYLS	OBS	CODE	EMIS	BBL	SEN	DISP	COMP	MILES	TEMP	BAROM	GR/LB	T	OCTANE	N	G	VAC	OCTANE	MPH	VAC	M	T	OCTANE	N	G	VAC
V-8	40L	SW	F	F	N	5.0	8.4	9099	98.	29.61	83.	M	94.0	K	3	1.0	92.5	25.	0.0	1	M	94.0	K	3	1.0
V-8	41L	SW	F	F	N	5.0	8.4	17758	99.	29.62	34.	M	95.5	K	2	0.0	93.0	52.	0.0	2	M	96.0	K	2	0.0
V-8	42L	SW	F	F	N	5.0	8.4	9950	91.	29.70	70.	M	94.0	K	2	0.0	92.0	49.	0.0	2	M	96.0	K	2	0.0
V-8	43L	SW	F	F	N	5.0	8.4	16179	94.	29.68	60.	M	95.5	K	2	0.0	94.0	55.	0.0	1	M	96.0	K	2	0.0
V-8	44L	SW	F	F	N	5.0	8.4	14141	93.	29.67	85.	M	94.0	K	2	0.5	94.0	43.	1.0	1	M	97.0	K	2	0.5
V-8	45L	SW	F	F	N	5.0	8.4	12673	80.	29.67	82.	M	91.5	K	3	0.0	89.0	30.	1.0	1	M	92.0	K	2	0.0
V-8	46L	SW	F	F	N	5.0	8.4	17295	83.	29.70	78.	M	94.0	K	D	0.5	92.0	45.	1.0	1	M	94.0	K	D	0.5
V-8	47L	SW	F	F	N	5.0	8.4	13168	98.	29.61	83.	M	94.5	K	D	0.5	94.0	42.	1.0	1	M	97.0	K	P	1.0
V-8	48L	SW	F	F	N	5.0	8.4	17527	77.	29.65	50.	M	94.0	K	4	2.0	94.0	45.	2.0	1	M	96.0	K	3	2.0
V-8	49L	SW	F	F	N	5.0	8.4	18651	107.	29.68	26.	M	94.0	K	3	0.0	93.5	45.	0.0	1	M	94.0	K	2	0.0

(RAW DATA - DENVER GROUP 4)

VEHICLE									WEATHER			FBRU MAX REQUIREMENTS					FBRU 50 PERCENTILE *				FBRSU MAX REQUIREMENTS				
CYLS	OBS	CODE	EMIS	BBL	SEN	DISP	COMP	MILES	TEMP	BAROM	GR/LB	T	OCTANE	N	G	VAC	OCTANE	MPH	VAC	M	T	OCTANE	N	G	VAC
V-8	40D	SW	F	F	N	5.0	8.4	8988	74.	24.78	76.	M	91.5	K	D	1.0	91.0	35.	0.0	2	M	92.5	K	D	3.0
V-8	41D	SW	F	F	N	5.0	8.4	17720	76.	24.70	68.	M	90.0	K	D	1.0	90.0	30.	0.0	1	M	91.5	K	D	1.0
V-8	42D	SW	F	F	N	5.0	8.4	9848	95.	24.56	63.	M	92.0	K	D	2.0	92.0	33.	0.0	3	M	93.0	K	D	2.0
V-8	43D	SW	F	F	N	5.0	8.4	16091	91.	24.57	59.	M	91.5	K	D	2.0	92.5	35.	0.0	1	M	92.0	K	D	0.0
V-8	44D	SW	F	F	N	5.0	8.4	14083	84.	24.76	76.	M	92.0	K	D	0.0	92.0	34.	2.5	1	M	93.0	K	D	0.0
V-8	45D	SW	F	F	N	5.0	8.4	12562	82.	24.53	63.	M	90.0	K	D	0.0	89.0	20.	0.0	1	M	91.5	K	D	0.0
V-8	46D	SW	F	F	N	5.0	8.4	17243	78.	24.62	82.	M	90.0	K	D	0.0	90.0	45.	2.0	1	M	91.0	K	D	0.0
V-8	47D	SW	F	F	N	5.0	8.4	13070	73.	24.66	88.	M	90.0	K	D	0.0	89.0	49.	0.5	1	M	92.0	K	D	0.0
V-8	48D	SW	F	F	N	5.0	8.4	17458	75.	24.62	96.	M	90.0	K	D	0.5	90.0	28.	2.5	1	M	91.0	K	D	0.5
V-8	49D	SW	F	F	N	5.0	8.4	18507	74.	24.80	76.	M	90.0	K	D	1.5	89.0	50.	2.0	2	M	91.0	K	D	1.5

NOTE: G = GEAR. M = MODE. N = NOISE. T = THROTTLE POS.

* 50th Percentile Acceleration Technique

1981 CRC ALTITUDE PROGRAM - 1981 VEHICLES (RAW DATA - LOS ANGELES GROUP 5)

VEHICLE									WEATHER			FBRU MAX REQUIREMENTS					FBRU 50 PERCENTILE*				FBRSU MAX REQUIREMENTS				
CYLS	OBS	CODE	EMIS	BBL	SEN	DISP	COMP	MILES	TEMP	BAROM	GR/LB	T	OCTANE	N	G	VAC	OCTANE	MPH	VAC	M	T	OCTANE	N	G	VAC
4	50L	KK	F	2	N	2.2	8.5	12192	75.	29.67	84.	M	100.0	K	D	2.0	100.0	40.	3.0	1	M	100.0	K	P	2.0
4	51L	KK	F	2	N	2.2	8.5	8270	98.	29.61	83.	M	88.0	K	D	1.5	88.0	45.	2.0	1	M	87.5	K	P	2.0
4	52L	KK	F	2	N	2.2	8.5	12330	106.	29.59	58.	M	94.0	K	D	1.5	94.0	45.	2.0	1	M	94.0	K	D	1.5
4	53L	KK	F	2	N	2.2	8.5	9450	110.	29.59	56.	M	88.0	K	M	0.0	87.5	40.	0.0	1	M	90.0	K	M	0.0
4	54L	KK	F	2	N	2.2	8.5	10470	83.	29.70	78.	M	94.0	K	D	1.0	94.0	30.	2.0	1	M	96.0	K	D	1.0
4	55L	KK	F	2	N	2.2	8.5	12730	92.	29.65	36.	M	93.0	K	P	2.0	94.0	30.	4.0	1	M	95.0	K	P	2.0
4	56L	KK	F	2	N	2.2	8.5	11840	85.	29.71	70.	M	89.0	K	P	1.5	89.0	50.	2.0	1	M	90.0	K	P	1.5
4	57L	KK	F	2	N	2.2	8.5	11128	104.	29.61	56.	M	96.0	K	D	2.0	96.0	25.	3.0	1	M	96.0	K	D	2.0
4	58L	KK	F	2	N	2.2	8.5	10075	110.	29.59	46.	M	98.0	K	D	2.0	99.0	30.	3.0	1	M	99.0	K	D	2.0
4	59L	KK	F	2	N	2.2	8.5	13809	78.	29.70	86.	M	87.0	K	P	0.0	86.0	35.	0.0	1	M	87.0	K	M	0.0

(RAW DATA - DENVER GROUP 5)

VEHICLE									WEATHER			FBRU MAX REQUIREMENTS					FBRU 50 PERCENTILE*				FBRSU MAX REQUIREMENTS				
CYLS	OBS	CODE	EMIS	BBL	SEN	DISP	COMP	MILES	TEMP	BAROM	GR/LB	T	OCTANE	N	G	VAC	OCTANE	MPH	VAC	M	T	OCTANE	N	G	VAC
4	50D	KK	F	2	N	2.2	8.5	11892	68.	24.76	65.	P	91.0	K	D	3.0	91.0	45.	3.0	2	M	91.0	K	D	2.0
4	51D	KK	F	2	N	2.2	8.5	8176	68.	24.76	66.	M	81.0	K	D	2.0	80.0	35.	2.0	1	M	82.0	K	D	2.0
4	52D	KK	F	2	N	2.2	8.5	12262	77.	24.76	71.	M	81.0	K	D	0.0	81.0	38.	0.0	1	M	84.0	K	D	0.0
4	53D	KK	F	2	N	2.2	8.5	9368	83.	24.60	94.	M	88.0	K	D	1.5	83.0	35.	2.0	1	M	88.0	K	P	1.5
4	54D	KK	F	2	N	2.2	8.5	10357	75.	24.60	96.	M	85.0	K	D	2.0	84.0	45.	2.0	3	M	86.0	K	D	2.0
4	55D	KK	F	2	N	2.2	8.5	12634	79.	24.78	89.	M	80.0	K	D	2.0	80.0	45.	2.0	3	M	82.0	K	D	2.0
4	56D	KK	F	2	N	2.2	8.5	11775	78.	24.60	86.	M	80.0	K	D	2.0	80.0	25.	2.0	1	M	84.0	K	D	2.0
4	57D	KK	F	2	N	2.2	8.5	11051	77.	24.73	82.	P	82.0	K	D	4.0	82.0	45.	2.0	3	M	82.0	K	D	2.0
4	58D	KK	F	2	N	2.2	8.5	9959	75.	24.63	96.	M	87.0	K	D	1.5	88.0	45.	1.0	2	M	89.0	K	D	1.5
4	59D	KK	F	2	N	2.2	8.5	13680	74.	24.80	75.	M	80.0	K	P	1.0	79.0	30.	1.0	1	M	81.0	K	D	1.0

NOTE: G = GEAR. M = MODE. N = NOISE. T = THROTTLE POS.

* 50th Percentile Acceleration Technique

1981 CRC ALTITUDE PROGRAM - 1981 VEHICLES (RAW DATA - LOS ANGELES GROUP 6)

VEHICLE									WEATHER			FBRU MAX REQUIREMENTS					FBRU 50 PERCENTILE*				FBRSU MAX REQUIREMENTS				
CYLS	OBS	CODE	EMIS	BBL	SEN	DISP	COMP	MILES	TEMP	BAROM	GR/LB	T	OCTANE	N	G	VAC	OCTANE	MPH	VAC	M	T	OCTANE	N	G	VAC
4	60L	MCA	B	2	N	2.3	9.0	12701	86.	29.73	84.	M	95.0	K	D	2.0	95.0	50.	2.0	1	M	95.0	K	D	2.0
4	61L	MCA	B	2	N	2.3	9.0	9235	81.	29.67	77.	M	93.0	K	D	0.0	93.0	55.	0.0	1	M	94.0	K	D	0.0
4	62L	MCA	B	2	N	2.3	9.0	11125	88.	29.68	76.	M	92.0	K	D	1.0	92.0	56.	1.0	1	M	94.0	K	D	1.0
4	63L	MCA	B	2	N	2.3	9.0	11375	91.	29.61	82.	M	93.0	K	P	1.0	92.0	54.	1.0	1	M	94.0	K	P	1.0
4	64L	MCA	B	2	N	2.3	9.0	15440	82.	29.69	70.	M	93.0	K	D	1.0	94.0	58.	1.0	2	M	93.0	K	D	1.0
4	65L	MCA	B	2	N	2.3	9.0	10243	88.	29.68	76.	M	94.0	K	D	0.0	94.5	55.	0.0	1	M	96.0	K	P	0.0
4	66L	MCA	B	2	N	2.3	9.0	14639	86.	29.64	74.	M	93.0	K	D	2.5	93.0	50.	2.5	1	M	93.0	K	D	2.5
4	67L	MCA	B	2	N	2.3	9.0	10000	93.	29.67	85.	M	90.0	K	D	0.0	90.0	55.	0.0	2	M	94.0	K	D	0.0
4	68L	MCA	B	2	N	2.3	9.0	12302	80.	29.72	77.	M	95.0	K	D	0.0	95.0	50.	0.0	1	M	96.0	K	D	0.0
4	69L	MCA	B	2	N	2.3	9.0	11084	86.	29.73	84.	M	94.0	K	D	2.0	95.0	50.	2.5	1	M	94.0	K	D	2.0

(RAW DATA - DENVER GROUP 6)

VEHICLE									WEATHER			FBRU MAX REQUIREMENTS					FBRU 50 PERCENTILE*				FBRSU MAX REQUIREMENTS				
CYLS	OBS	CODE	EMIS	BBL	SEN	DISP	COMP	MILES	TEMP	BAROM	GR/LB	T	OCTANE	N	G	VAC	OCTANE	MPH	VAC	M	T	OCTANE	N	G	VAC
4	60D	MCA	B	2	N	2.3	9.0	12613	80.	24.70	82.	M	84.0	K	P	2.0	84.0	35.	2.0	1	M	85.0	K	P	2.0
4	61D	MCA	B	2	N	2.3	9.0	9113	87.	24.55	72.	M	83.0	K	D	1.0	84.0	45.	1.0	1	M	84.5	K	D	1.0
4	62D	MCA	B	2	N	2.3	9.0	11080	76.	24.70	68.	M	85.0	K	D	1.0	85.0	54.	1.0	3	M	87.0	K	D	1.0
4	63D	MCA	B	2	N	2.3	9.0	11291	76.	24.70	68.	M	85.0	K	D	1.0	85.0	46.	2.0	1	M	87.0	K	D	1.0
4	64D	MCA	B	2	N	2.3	9.0	15391	74.	24.66	75.	M	86.0	K	D	1.0	86.0	35.	2.5	1	M	88.0	K	D	1.0
4	65D	MCA	B	2	N	2.3	9.0	10107	86.	24.67	84.	M	86.0	K	D	1.0	85.5	54.	1.0	1	M	88.5	K	P	0.0
4	66D	MCA	B	2	N	2.3	9.0	14535	74.	24.66	75.	M	82.0	K	P	2.0	84.0	25.	3.0	1	M	84.0	K	D	2.0
4	67D	MCA	B	2	N	2.3	9.0	9816	80.	24.67	80.	M	83.0	K	D	0.0	83.0	45.	1.0	2	M	85.0	K	D	1.0
4	68D	MCA	B	2	N	2.3	9.0	12196	74.	24.66	75.	M	84.5	K	P	1.5	84.5	28.	1.5	1	M	86.0	K	P	1.5
4	69D	MCA	B	2	N	2.3	9.0	11011	69.	24.68	68.	M	83.0	K	D	0.0	83.0	48.	0.0	1	M	83.0	K	D	0.0

NOTE: G = GEAR. M = MODE. N = NOISE. T = THROTTLE POS.

* 50th Percentile Acceleration Technique

1981 CRC ALTITUDE PROGRAM - 1981 VEHICLES (RAW DATA - LOS ANGELES GROUP 7)

VEHICLE									WEATHER			FBRU MAX REQUIREMENTS					FBRU 50 PERCENTILE*				FBRSU MAX REQUIREMENTS				
CYLS	OBS	CODE	EMIS	BBL	SEN	DISP	COMP	MILES	TEMP	BAROM	GR/LB	T	OCTANE	N	G	VAC	OCTANE	MPH	VAC	M	T	OCTANE	N	G	VAC
4	70L	LC5	B	2	N	2.5	8.2	6862	91.	29.60	82.	M	92.0	K	D	0.0	91.0	40.	0.0	1	M	96.0	K	D	0.0
4	71L	LC5	B	2	N	2.5	8.2	7000	72.	29.71	82.	M	94.0	K	D	2.0	94.0	50.	2.0	2	M	97.0	K	D	2.0
4	72L	LC5	B	2	N	2.5	8.2	5139	89.	29.71	70.	M	99.0	K	D	2.0	99.0	40.	3.0	1	M	99.0	K	D	2.0
4	73L	LC5	B	2	N	2.5	8.2	5750	91.	29.70	66.	M	91.0	K	D	2.0	92.0	35.	4.0	1	M	92.0	K	D	2.0
4	74L	LC5	B	2	N	2.5	8.2	7016	91.	29.68	82.	M	94.0	K	D	2.0	95.0	30.	4.0	1	M	95.0	K	D	2.0
4	75L	LC5	B	2	N	2.5	8.2	8279	88.	29.68	76.	M	99.0	K	D	2.0	98.0	35.	3.5	1	M	99.0	K	D	2.0
4	76L	LC5	B	2	N	2.5	8.2	6720	91.	29.61	82.	M	99.0	K	D	2.0	99.0	25.	3.0	1	M	99.0	K	D	2.0
4	77L	LC5	B	2	N	2.5	8.2	5994	81.	29.67	77.	M	98.0	K	D	2.0	98.0	15.	7.0	1	M	98.0	K	P	2.0
4	78L	LC5	B	2	N	2.5	8.2	6250	93.	29.67	85.	M	94.0	K	D	2.0	94.0	25.	4.0	1	M	94.0	K	D	2.0
4	79L	LC5	B	2	N	2.5	8.2	5300	86.	29.73	77.	M	87.0	K	D	1.0	86.0	36.	1.0	1	M	89.0	K	D	1.0

(RAW DATA - DENVER GROUP 7)

VEHICLE									WEATHER			FBRU MAX REQUIREMENTS					FBRU 50 PERCENTILE*				FBRSU MAX REQUIREMENTS				
CYLS	OBS	CODE	EMIS	BBL	SEN	DISP	COMP	MILES	TEMP	BAROM	GR/LB	T	OCTANE	N	G	VAC	OCTANE	MPH	VAC	M	T	OCTANE	N	G	VAC
4	70D	LC5	B	2	N	2.5	8.2	6730	79.	24.78	89.	M	85.5	K	D	0.0	83.0	33.	0.0	1	M	88.5	K	D	0.0
4	71D	LC5	B	2	N	2.5	8.2	6870	91.	24.57	59.	M	85.0	K	P	1.0	83.0	53.	1.0	1	M	86.5	K	D	1.0
4	72D	LC5	B	2	N	2.5	8.2	5087	95.	24.56	63.	P	96.0	K	D	5.0	96.0	25.	3.0	1	P	96.0	K	D	5.0
4	73D	LC5	B	2	N	2.5	8.2	5687	91.	24.56	59.	M	84.0	K	D	2.0	84.0	35.	2.0	3	M	84.0	K	D	2.0
4	74D	LC5	B	2	N	2.5	8.2	6924	89.	24.57	69.	M	84.0	K	P	2.0	85.0	30.	2.0	3	M	85.0	K	D	2.0
4	75D	LC5	B	2	N	2.5	8.2	8117	69.	24.68	68.	M	93.0	K	P	2.0	93.0	45.	2.0	3	M	93.0	K	P	2.0
4	76D	LC5	B	2	N	2.5	8.2	6645	76.	24.70	68.	M	88.0	K	D	2.0	88.0	40.	2.0	1	M	88.0	K	D	2.0
4	77D	LC5	B	2	N	2.5	8.2	5904	86.	24.67	84.	M	90.0	K	D	2.0	91.0	30.	4.0	1	M	91.0	K	D	2.0
4	78D	LC5	B	2	N	2.5	8.2	6138	82.	24.53	63.	M	90.0	K	D	2.0	90.0	35.	2.0	3	M	90.0	K	D	2.0
4	79D	LC5	B	2	N	2.5	8.2	5241	82.	24.53	63.	M	80.0	K	D	2.0	80.0	25.	2.0	1	M	83.0	K	D	2.0

NOTE: G = GEAR. M = MODE. N = NOISE. T = THROTTLE POS.

* 50th Percentile Acceleration Technique

(RAW DATA - LOS ANGELES GROUP 8A)

1981 CRC ALTITUDE PROGRAM - 1981 VEHICLES

VEHICLE									WEATHER			FBRU MAX REQUIREMENTS					FBRU 50 PERCENTILE *				FBRSU MAX REQUIREMENTS				
CYLS	OBS	CODE	EMIS	BBL	SEN	DISP	COMP	MILES	TEMP	BAROM	GR/LB	T	OCTANE	N	G	VAC	OCTANE	MPH	VAC	M	T	OCTANE	N	G	VAC
V-6	1L	LR	F	4	N	4.1	8.0	4500	84.	29.71	67.	P	94.0	K	3	5.0	91.5	35.	4.0	1	P	94.0	K	D	5.0
V-6	2L	GE	F	4	N	4.1	8.0	6575	95.	29.70	64.	M	88.0	K	D	1.0	88.0	50.	2.0	1	M	92.0	K	P	1.0
V-6	5L	IR	F	4	N	4.1	8.0	2368	92.	29.67	75.	P	90.0	K	D	4.0	88.0	50.	0.0	1	P	94.0	K	D	4.0

(RAW DATA - DENVER GROUP 8A)

VEHICLE									WEATHER			FBRU MAX REQUIREMENTS					FBRU 50 PERCENTILE *				FBRSU MAX REQUIREMENTS				
CYLS	OBS	CODE	EMIS	BBL	SEN	DISP	COMP	MILES	TEMP	BAROM	GR/LB	T	OCTANE	N	G	VAC	OCTANE	MPH	VAC	M	T	OCTANE	N	G	VAC
V-6	1D	LR	F	4	N	4.1	8.0	4320	74.	24.66	75.	M	81.0	K	D	2.0	80.0	33.	3.0	1	M	82.0	K	D	2.0
V-6	2D	GE	F	4	N	4.1	8.0	6495	69.	24.68	69.	M	82.0	K	D	2.0	82.0	45.	2.5	1	M	85.0	K	D	2.0
V-6	5D	IR	F	4	N	4.1	8.0	2200	87.	24.55	72.	M	82.0	K	D	2.0	81.0	50.	2.0	3	M	86.0	K	D	2.0

NOTE: G = GEAR. M = MODE. N = NOISE. T = THROTTLE.

* 50th Percentile Acceleration Technique

1981 CRC ALTITUDE PROGRAM - 1981 VEHICLES

(RAW DATA - LOS ANGELES GROUP 8B)

VEHICLE									WEATHER			REQ'T	FBRU REQUIREMENTS								FBRSU REQUIREMENTS			
													MAX THROTTLE				50 PERCENTILE*				MAX THROTTLE			
CYLS	OBS	CODE	EMIS	BBL	SEN	DISP	COMP	MILES	TEMP	BAROM	GR/LB	TYPE	OCTANE	N	G	VAC	OCTANE	MPH	VAC	M	OCTANE	N	G	VAC
V-6	3L	LX	F	4	Y	4.1	8.0	7104	85.	29.70	69.	E-15	93.0	K	P	1.0	92.0	50.	2.0	1	93.0	K	P	1.0
												MIN	82.0	K	P	1.0	80.0	42.	1.0	3	80.0	K	P	1.0
												MAX	95.0	K	P	1.0	93.0	--	---	-	97.0	K	P	1.0
V-6	4L	LX	F	4	Y	4.1	8.0	3570	73.	29.67	92.	E-15	99.0	K	P	2.0	98.0	51.	2.0	1	101.0	K	P	2.0
												MIN	86.0	K	P	2.0	85.0	48.	2.0	3	86.0	K	P	2.0
												MAX	100.0	K	P	2.0	100.0	50.	2.0	3	101.0	K	P	2.0
V-6	6L	GF	F	4	Y	4.1	8.0	4690	82.	29.69	70.	E-15	97.0	K	D	2.0	98.0	45.	2.0	2	97.0	K	D	2.0
												MIN	94.0	K	D	2.0	96.0	48.	2.0	3	93.0	K	D	2.0
												MAX	100.0	K	D	2.0	100.0	--	---	-	101.0	K	D	2.0

(RAW DATA - DENVER GROUP 8B)

VEHICLE									WEATHER			REQ'T	FBRU REQUIREMENTS								FBRSU REQUIREMENTS			
													MAX THROTTLE				50 PERCENTILE*				MAX THROTTLE			
CYLS	OBS	CODE	EMIS	BBL	SEN	DISP	COMP	MILES	TEMP	BAROM	GR/LB	TYPE	OCTANE	N	G	VAC	OCTANE	MPH	VAC	M	OCTANE	N	G	VAC
V-6	3D	LX	F	4	Y	4.1	8.0	6944	91.	24.55	60.	E-15	88.0	K	P	1.0	88.0	45.	1.0	1	89.0	K	P	1.0
												MIN	78.0	K	P	1.0	78.0	--	---	-	80.0	K	P	1.0
												MAX	89.0	K	P	1.0	89.0	--	---	-	91.0	K	P	1.0
V-6	4D	LX	F	4	Y	4.1	8.0	3390	86.	24.55	83.	E-15	98.0	K	P	1.0	98.0	45.	1.0	1	101.0	K	P	1.0
												MIN	82.0	K	P	1.0	78.0	50.	1.0	3	84.0	K	P	1.0
												MAX	100.0	K	P	1.0	100.0	--	---	-	101.0	K	P	1.0
V-6	6D	GF	F	4	Y	4.1	8.0	4420	69.	24.55	68.	E-15	93.0	K	P	2.0	93.0	45.	2.0	1	95.0	K	P	2.0
												MIN	90.0	K	P	2.0	92.0	35.	2.0	2	88.0	K	P	1.0
												MAX	95.0	K	P	2.0	99.0	--	---	-	99.0	K	P	2.0

NOTE: G = GEAR. M = MODE. N = NOISE.

* 50th Percentile Acceleration Technique

APPENDIX G

SUMMARY OF INDIVIDUAL CAR DATA

(RAW DATA AND WEATHER-CORRECTED DATA)

1981 CRC ALTITUDE PROGRAM - 1981 VEHICLES

GROUP 1

RAW DATA

DESV NO.	FBRU MAX L.A.	FBRU MAX DENVER	FBRU MAX DIFF	FBRU 50%* L.A.	FBRU 50%* DENVER	FBRU 50%* DIFF	FBRSU MAX L.A.	FBRSU MAX DENVER	FBRSU MAX DIFF
10	87.5	83.0	4.5	87.5	78.0	9.5	87.5	83.0	4.5
11	88.0	81.0	7.0	88.0	80.0	8.0	91.0	82.0	9.0
12	92.0	85.0	7.0	92.0	85.0	7.0	93.0	85.0	8.0
13	86.0	80.0	6.0	84.0	78.0	6.0	87.0	82.0	5.0
14	86.0	80.0	6.0	84.0	78.0	6.0	87.0	81.0	6.0
15	87.0	83.0	4.0	85.0	79.0	6.0	87.5	84.0	3.5
16	90.0	80.0	10.0	90.0	78.0	12.0	91.0	80.0	11.0
17	95.0	82.0	13.0	96.0	84.0	12.0	96.0	84.0	12.0
18	90.0	81.0	9.0	90.5	79.0	11.5	92.0	83.0	9.0
19	85.0	80.0	5.0	85.0	78.0	7.0	87.0	82.0	5.0
MEAN	88.7	81.5	7.2	88.2	79.7	8.5	89.9	82.6	7.3
STD DEV	3.1	1.7	2.8	3.9	2.6	2.5	3.2	1.5	2.9

GROUP 1

WEATHER-CORRECTED DATA

DESV NO.	FBRU MAX L.A.	FBRU MAX DENVER	FBRU MAX DIFF	FBRU 50%* L.A.	FBRU 50%* DENVER	FBRU 50%* DIFF	FBRSU MAX L.A.	FBRSU MAX DENVER	FBRSU MAX DIFF
10	85.9	82.7	3.2	85.9	77.7	8.2	85.9	82.7	3.2
11	88.4	80.7	7.7	88.4	79.7	8.7	91.4	81.7	9.7
12	91.5	85.9	5.6	91.5	85.9	5.6	92.5	85.9	6.6
13	85.3	79.8	5.5	83.3	77.8	5.5	86.3	81.8	4.5
14	86.9	80.3	6.6	84.9	78.3	6.6	87.9	81.3	6.6
15	86.5	84.3	2.2	84.5	80.3	4.2	87.0	85.3	1.7
16	89.6	79.7	9.9	89.6	77.7	11.9	90.6	79.7	10.9
17	94.1	83.0	11.1	95.1	85.0	10.1	95.1	85.0	10.1
18	89.0	80.8	8.2	89.5	78.8	10.7	91.0	82.8	8.2
19	84.3	80.9	3.4	84.3	78.9	5.4	86.3	82.9	3.4
MEAN	88.2	81.9	6.3	87.8	80.1	7.6	89.5	83.0	6.4
STD DEV	3.0	2.1	2.9	3.8	3.0	2.6	3.2	2.0	3.2

* 50th Percentile Acceleration Technique

1981 CRC ALTITUDE PROGRAM - 1981 VEHICLES

GROUP 2

RAW DATA

OBSV NO.	FBRU MAX L.A.	FBRU MAX DENVER	FBRU MAX DIFF	FBRU 50%* L.A.	FBRU 50%* DENVER	FBRU 50%* DIFF	FBRSU MAX L.A.	FBRSU MAX DENVER	FBRSU MAX DIFF
20	90.0	87.0	3.0	90.0	88.0	2.0	92.0	90.0	2.0
21	91.0	85.0	6.0	89.0	85.0	4.0	93.0	87.0	6.0
22	94.0	88.0	6.0	92.0	88.0	4.0	95.0	90.0	5.0
23	88.0	87.0	1.0	88.0	84.0	4.0	90.0	88.0	2.0
24	91.0	88.0	3.0	91.0	88.0	3.0	92.0	90.0	2.0
25	90.0	88.0	2.0	89.0	88.0	1.0	92.0	89.0	3.0
26	90.0	86.0	4.0	90.0	86.0	4.0	91.0	88.0	3.0
27	88.0	86.0	2.0	87.0	85.0	2.0	89.0	88.0	1.0
28	91.0	89.0	2.0	91.0	87.0	4.0	93.0	89.5	3.5
29	93.0	91.5	1.5	93.0	91.0	2.0	97.0	92.0	5.0
MEAN	90.6	87.6	3.1	90.0	87.0	3.0	92.4	89.2	3.3
STD DEV	1.9	1.8	1.8	1.8	2.1	1.2	2.3	1.5	1.6

GROUP 2

WEATHER-CORRECTED DATA

OBSV NO.	FBRU MAX L.A.	FBRU MAX DENVER	FBRU MAX DIFF	FBRU 50%* L.A.	FBRU 50%* DENVER	FBRU 50%* DIFF	FBRSU MAX L.A.	FBRSU MAX DENVER	FBRSU MAX DIFF
20	90.4	87.3	3.1	90.4	88.3	2.1	92.4	90.3	2.1
21	90.3	85.6	4.7	88.3	85.6	2.7	92.3	87.6	4.7
22	93.7	88.9	4.8	91.7	88.9	2.8	94.7	90.9	3.8
23	88.4	88.0	0.4	88.4	85.0	3.4	90.4	89.0	1.4
24	90.1	87.7	2.4	90.1	87.7	2.4	91.1	89.7	1.4
25	89.2	88.6	0.6	88.2	88.6	-0.4	91.2	89.6	1.6
26	90.0	85.2	4.8	90.0	85.2	4.8	91.0	87.2	3.8
27	88.5	85.8	2.7	87.5	84.8	2.7	89.5	87.8	1.7
28	91.7	88.2	3.5	91.7	86.2	5.5	93.7	88.7	5.0
29	91.4	92.1	-0.7	91.4	91.6	-0.2	95.4	92.6	2.8
MEAN	90.4	87.8	2.6	89.5	87.2	2.5	92.2	89.4	2.8
STD DEV	1.6	2.0	2.0	1.6	2.2	1.9	1.9	1.7	1.4

* 50th Percentile Acceleration Technique

1981 CRC ALTITUDE PROGRAM - 1981 VEHICLES

GROUP 3

RAW DATA

CRSV	EBRU MAX			EBRU 50%*			EBRSU MAX		
NO.	L.A.	DENVER	DIFF	L.A.	DENVER	DIFF	L.A.	DENVER	DIFF
30	87.0	79.0	8.0	85.0	78.0	7.0	87.0	81.0	6.0
31	89.0	80.0	9.0	89.0	78.0	11.0	91.0	81.0	10.0
32	86.0	79.0	7.0	85.0	79.0	6.0	89.0	81.0	8.0
33	88.0	80.0	8.0	89.0	80.0	9.0	90.0	82.0	8.0
34	89.0	80.0	9.0	88.0	80.0	8.0	90.0	82.0	8.0
35	89.0	80.0	9.0	88.0	80.0	8.0	90.0	82.0	8.0
36	90.0	80.0	10.0	90.0	78.0	12.0	92.0	80.0	12.0
37	89.0	80.0	9.0	88.0	80.0	8.0	88.0	81.0	7.0
38	88.0	80.0	8.0	88.5	80.0	8.5	89.0	84.0	5.0
39	94.0	84.0	10.0	94.0	84.0	10.0	95.0	86.0	9.0
MEAN	89.9	80.2	8.7	88.5	79.7	8.8	90.1	82.0	8.1
STD DEV	2.1	1.4	0.9	2.5	1.8	1.8	2.2	1.8	2.0

GROUP 3

WEATHER-CORRECTED DATA

CRSV	EBRU MAX			EBRU 50%*			EBRSU MAX		
NO.	L.A.	DENVER	DIFF	L.A.	DENVER	DIFF	L.A.	DENVER	DIFF
30	87.0	79.2	7.8	85.0	78.2	6.8	87.0	81.2	5.8
31	86.2	80.4	5.8	86.2	78.4	7.8	88.2	81.4	6.8
32	85.0	79.7	5.3	84.0	79.7	4.3	88.0	81.7	6.3
33	86.9	80.7	6.2	87.9	80.7	7.2	88.9	82.7	6.2
34	88.2	80.7	7.5	87.2	80.7	6.5	89.2	82.7	6.5
35	87.3	80.7	6.6	86.3	80.7	5.6	88.3	82.7	5.6
36	87.7	80.7	7.0	87.7	78.7	9.0	89.7	80.7	9.0
37	86.2	80.2	6.0	85.2	80.2	5.0	85.2	81.2	4.0
38	87.6	80.7	6.9	88.1	80.7	7.4	88.6	84.7	3.9
39	94.7	84.7	10.0	94.7	84.7	10.0	95.7	86.7	9.0
MEAN	87.7	80.8	6.9	87.3	80.3	6.9	88.9	82.6	6.3
STD DEV	2.6	1.5	1.3	3.0	1.9	1.7	2.7	1.9	1.7

* 50th Percentile Acceleration Technique

1981 CRC ALTITUDE PROGRAM - 1981 VEHICLES

GROUP 4

RAW DATA

OBSV NO.	FBRU MAX			FBRU 50%*			FBRSU MAX		
	L.A.	DENVER	DIFF	L.A.	DENVER	DIFF	L.A.	DENVER	DIFF
40	94.0	91.5	2.5	92.5	91.0	1.5	94.0	92.5	1.5
41	95.5	90.0	5.5	93.0	90.0	3.0	96.0	91.5	4.5
42	94.0	92.0	2.0	92.0	92.0	0.0	96.0	93.0	3.0
43	95.5	91.5	4.0	94.0	92.5	1.5	96.0	92.0	4.0
44	94.0	92.0	2.0	94.0	92.0	2.0	97.0	93.0	4.0
45	91.5	90.0	1.5	89.0	89.0	0.0	92.0	91.5	0.5
46	94.0	90.0	4.0	92.0	90.0	2.0	94.0	91.0	3.0
47	94.5	90.0	4.5	94.0	89.0	5.0	97.0	92.0	5.0
48	94.0	90.0	4.0	94.0	90.0	4.0	96.0	91.0	5.0
49	94.0	90.0	4.0	93.5	89.0	4.5	94.0	91.0	3.0
MEAN	94.1	90.7	3.4	92.8	90.5	2.4	95.2	91.9	3.4
STD DEV	1.1	0.9	1.3	1.6	1.3	1.7	1.6	0.8	1.5

GROUP 4

WEATHER-CORRECTED DATA

OBSV NO.	FBRU MAX			FBRU 50%*			FBRSU MAX		
	L.A.	DENVER	DIFF	L.A.	DENVER	DIFF	L.A.	DENVER	DIFF
40	93.6	92.2	1.4	92.1	91.7	0.4	93.6	93.2	0.4
41	93.4	90.3	3.1	90.9	90.3	0.6	93.9	91.8	2.1
42	93.6	91.1	2.5	91.6	91.1	0.5	95.6	92.1	3.5
43	94.6	90.7	3.9	93.1	91.7	1.4	95.1	91.2	3.9
44	94.0	92.2	1.8	94.0	92.2	1.8	97.0	93.2	3.8
45	92.1	89.8	2.3	89.6	88.8	0.8	92.6	91.3	1.3
46	94.3	90.7	3.6	92.3	90.7	1.6	94.3	91.7	2.6
47	94.1	91.2	2.9	93.6	90.2	3.4	96.6	93.2	3.4
48	93.6	91.3	2.3	93.6	91.3	2.3	95.6	92.3	3.3
49	91.2	90.7	0.5	90.7	89.7	1.0	91.2	91.7	-0.5
MEAN	93.5	91.1	2.4	92.2	90.8	1.3	94.6	92.2	2.3
STD DEV	1.0	0.8	1.0	1.5	1.0	0.9	1.8	0.8	1.5

* 50th Percentile Acceleration Technique

1981 CRC ALTITUDE PROGRAM - 1981 VEHICLES

GROUP 5

RAW DATA

OBSV NO.	FBRU MAX			FBRU 50%*			FBRSU MAX		
	L.A.	DENVER	DIFF	L.A.	DENVER	DIFF	L.A.	DENVER	DIFF
50	100.0	91.0	9.0	101.0	91.0	10.0	100.0	91.0	9.0
51	88.0	81.0	7.0	88.0	80.0	8.0	87.5	82.0	5.5
52	94.0	81.0	13.0	94.0	81.0	13.0	94.0	84.0	10.0
53	88.0	88.0	0.0	87.5	83.0	4.5	90.0	88.0	2.0
54	94.0	85.0	9.0	94.0	84.0	10.0	96.0	86.0	10.0
55	93.0	80.0	13.0	94.0	80.0	14.0	95.0	82.0	13.0
56	89.0	80.0	9.0	89.0	80.0	9.0	90.0	84.0	6.0
57	96.0	82.0	14.0	96.0	82.0	14.0	96.0	82.0	14.0
58	98.0	87.0	11.0	99.0	88.0	11.0	99.0	89.0	10.0
59	87.0	80.0	7.0	86.0	79.0	7.0	87.0	81.0	6.0
MEAN	92.7	83.5	9.2	92.9	82.8	10.1	93.5	84.9	8.6
STD DEV	4.5	4.0	4.1	5.1	3.9	3.1	4.6	3.4	3.7

GROUP 5

WEATHER-CORRECTED DATA

OBSV NO.	FBRU MAX			FBRU 50%*			FBRSU MAX		
	L.A.	DENVER	DIFF	L.A.	DENVER	DIFF	L.A.	DENVER	DIFF
50	100.9	91.6	9.3	101.9	91.6	10.3	100.9	91.6	9.3
51	87.6	81.7	5.9	87.6	80.7	6.9	87.1	82.7	4.4
52	92.3	81.4	10.9	92.3	81.4	10.9	92.3	84.4	7.9
53	86.1	88.8	-2.7	85.6	83.8	1.8	88.1	88.8	-0.7
54	94.3	86.3	8.0	94.3	85.3	9.0	96.3	87.3	9.0
55	91.3	80.9	10.4	92.3	80.9	11.4	93.3	82.9	10.4
56	88.9	80.8	8.1	88.9	80.8	8.1	89.9	84.8	5.1
57	94.4	82.7	11.7	94.4	82.7	11.7	94.4	82.7	11.7
58	95.7	88.3	7.4	96.7	89.3	7.4	96.7	90.3	6.4
59	87.8	80.7	7.1	86.8	79.7	7.1	87.8	81.7	6.1
MEAN	92.0	84.4	7.6	92.1	83.7	8.4	92.7	85.8	6.9
STD DEV	4.5	4.1	4.1	5.0	4.0	3.0	4.5	3.5	3.6

* 50th Percentile Acceleration Technique

1981 CRC ALTITUDE PROGRAM - 1981 VEHICLES

GROUP 6

RAW DATA

OBSV NO.	EBRU MAX L.A.	EBRU MAX DENVER	EBRU MAX DIFF	EBRU 50%* L.A.	EBRU 50%* DENVER	EBRU 50%* DIFF	EBRSU MAX L.A.	EBRSU MAX DENVER	EBRSU MAX DIFF
60	95.0	84.0	11.0	95.0	84.0	11.0	95.0	85.0	10.0
61	93.0	83.0	10.0	93.0	84.0	9.0	94.0	84.5	9.5
62	92.0	85.0	7.0	92.0	85.0	7.0	94.0	87.0	7.0
63	93.0	85.0	8.0	92.0	85.0	7.0	94.0	87.0	7.0
64	93.0	86.0	7.0	94.0	86.0	8.0	93.0	88.0	5.0
65	94.0	86.0	8.0	94.5	85.5	9.0	96.0	88.5	7.5
66	93.0	82.0	11.0	93.0	84.0	9.0	93.0	84.0	9.0
67	90.0	83.0	7.0	90.0	83.0	7.0	94.0	85.0	9.0
68	95.0	84.5	10.5	95.0	84.5	10.5	96.0	86.0	10.0
69	94.0	83.0	11.0	95.0	83.0	12.0	94.0	83.0	11.0
MEAN	93.2	84.2	9.1	93.4	84.4	9.0	94.3	85.8	8.5
STD DEV	1.5	1.4	1.8	1.7	1.0	1.8	1.1	1.8	1.8

GROUP 6

WEATHER-CORRECTED DATA

OBSV NO.	EBRU MAX L.A.	EBRU MAX DENVER	EBRU MAX DIFF	EBRU 50%* L.A.	EBRU 50%* DENVER	EBRU 50%* DIFF	EBRSU MAX L.A.	EBRSU MAX DENVER	EBRSU MAX DIFF
60	95.3	84.6	10.7	95.3	84.6	10.7	95.3	85.6	9.7
61	93.4	82.9	10.5	93.4	83.9	9.5	94.4	84.4	10.0
62	91.9	85.3	6.6	91.9	85.3	6.6	93.9	87.3	6.6
63	93.0	85.3	7.7	92.0	85.3	6.7	94.0	87.3	6.7
64	93.1	86.7	6.4	94.1	86.7	7.4	93.1	88.7	4.4
65	93.9	86.3	7.6	94.4	85.8	8.6	95.9	88.8	7.1
66	93.0	82.7	10.3	93.0	84.7	8.3	93.0	84.7	8.3
67	90.0	83.5	6.5	90.0	83.5	6.5	94.0	85.5	8.5
68	95.4	85.2	10.2	95.4	85.2	10.2	96.4	86.7	9.7
69	94.3	83.7	10.6	95.3	83.7	11.6	94.3	83.7	10.6
MEAN	93.4	84.7	8.7	93.5	84.9	8.6	94.5	86.3	8.1
STD DEV	1.6	1.4	1.9	1.8	1.0	1.8	1.1	1.8	1.9

* 50th Percentile Acceleration Technique

1981 CBC ALTITUDE PROGRAM - 1981 VEHICLES

GROUP 7

RAW DATA

OBSV NO.	EBBU MAX L.A.	EBBU MAX DENVER	EBBU MAX DIFF	EBBU 50%* L.A.	EBBU 50%* DENVER	EBBU 50%* DIFF	EBRSU MAX L.A.	EBRSU MAX DENVER	EBRSU MAX DIFF
70	92.0	85.5	6.5	91.0	83.0	8.0	96.0	88.5	7.5
71	94.0	85.0	9.0	94.0	83.0	11.0	97.0	86.5	10.5
72	99.0	96.0	3.0	99.0	96.0	3.0	99.0	96.0	3.0
73	91.0	84.0	7.0	92.0	84.0	8.0	92.0	84.0	8.0
74	94.0	84.0	10.0	95.0	85.0	10.0	95.0	85.0	10.0
75	99.0	93.0	6.0	98.0	93.0	5.0	99.0	93.0	6.0
76	99.0	88.0	11.0	99.0	88.0	11.0	99.0	88.0	11.0
77	98.0	90.0	8.0	98.0	91.0	7.0	98.0	91.0	7.0
78	94.0	90.0	4.0	94.0	90.0	4.0	94.0	90.0	4.0
79	87.0	80.0	7.0	86.0	80.0	6.0	89.0	83.0	6.0
MEAN	94.7	87.6	7.2	94.6	87.3	7.3	95.8	88.5	7.3
STD DEV	4.1	4.8	2.5	4.2	5.1	2.8	3.4	4.1	2.7

GROUP 7

WEATHER-CORRECTED DATA

OBSV NO.	EBBU MAX L.A.	EBBU MAX DENVER	EBBU MAX DIFF	EBBU 50%* L.A.	EBBU 50%* DENVER	EBBU 50%* DIFF	EBRSU MAX L.A.	EBRSU MAX DENVER	EBRSU MAX DIFF
70	92.0	86.4	5.6	91.0	83.9	7.1	96.0	89.4	6.6
71	95.0	84.2	10.8	95.0	82.2	12.8	98.0	85.7	12.3
72	98.7	95.1	3.6	98.7	95.1	3.6	98.7	95.1	3.6
73	90.4	83.2	7.2	91.4	83.2	8.2	91.4	83.2	8.2
74	94.0	83.6	10.4	95.0	84.6	10.4	95.0	84.6	10.4
75	98.9	93.7	5.2	97.9	93.7	4.2	98.9	93.7	5.2
76	99.0	88.3	10.7	99.0	88.3	10.7	99.0	88.3	10.7
77	98.4	90.3	8.1	98.4	91.3	7.1	98.4	91.3	7.1
78	94.0	89.8	4.2	94.0	89.8	4.2	94.0	89.8	4.2
79	87.1	79.8	7.3	86.1	79.8	6.3	89.1	82.8	6.3
MEAN	94.8	87.5	7.3	94.7	87.2	7.4	95.9	88.4	7.4
STD DEV	4.1	4.9	2.7	4.2	5.2	3.1	3.5	4.3	2.9

* 50th Percentile Acceleration Technique

1981 CRC ALTITUDE PROGRAM - 1981 VEHICLES

GROUP 8A

(Cars Without Knocksensors)

RAW DATA

OBSV. NO.	FBRU MAX LA	FBRU MAX Denver	FBRU MAX Diff.	FBRU 50%** LA	FBRU 50%** Denver	FBRU 50%** Diff.	FBRSU MAX LA	FBRSU MAX Denver	FBRSU MAX Diff.
1	94.0	81.0	13.0	91.5	80.0	11.5	94.0	82.0	12.0
2	88.0	82.0	6.0	88.0	82.0	6.0	92.0	85.0	7.0
5	90.0	82.0	8.0	88.0	81.0	7.0	94.0	86.0	8.0
MEAN	90.7	81.7	9.0	89.2	81.0	8.2	93.3	84.3	9.0
STD.DEV.	3.1	0.6	3.6	2.0	1.0	2.9	1.2	2.1	2.7

GROUP 8A

WEATHER-CORRECTED DATA

OBSV. NO.	FBRU MAX LA	FBRU MAX Denver	FBRU MAX Diff.	FBRU 50%** LA	FBRU 50%** Denver	FBRU 50%** Diff.	FBRSU MAX LA	FBRSU MAX Denver	FBRSU MAX Diff.
1	93.8	81.7	12.1	91.3	80.7	10.6	93.8	82.7	11.1
2	87.1	82.7	4.4	87.1	82.7	4.4	91.1	85.7	5.4
5	89.7	81.9	7.8	87.7	80.9	6.8	93.7	85.9	7.8
MEAN	90.2	82.1	8.1*	88.7	81.4	7.3*	92.9	84.8	8.1
STD.DEV.	3.4	0.5	3.9	2.3	1.1	3.1	1.5	1.8	2.9

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* Not statistically significant at the 95% confidence level.

** 50th Percentile Acceleration Technique.

1981 CRC ALTITUDE PROGRAM - 1981 VEHICLES

GROUP 8B

(Cars With Knocksensors)

RAW DATA

OBSV. NO.	FBRU LA	FBRU Denver	FBRU Diff.	FBRU 50%+ LA	FBRU 50%+ Denver	FBRU 50%+ Diff.	FBRSU LA	FBRSU Denver	FBRSU Diff.
Minimum Octane Requirement									
3	82.0	78.0	4.0	80.0	78.0*	2.0	80.0	80.0	0.0
4	86.0	82.0	4.0	85.0	78.0	7.0	86.0	84.0	2.0
6	94.0	90.0	4.0	96.0	92.0	4.0	93.0	88.0	5.0
MEAN	87.3	83.3	4.0	87.0	82.7	4.3***	86.3	84.0	2.3***
STD.DEV.	6.1	6.1	0.0	8.2	8.1	2.5	6.5	4.0	2.5
Maximum Octane Requirement									
3	95.0	89.0	6.0	93.0	89.0	4.0	97.0	91.0	6.0
4	100.0**	100.0	0.0	100.0**	100.0	0.0	101.0**	101.0**	0.0
6	100.0	95.0	5.0	100.0**	99.0	1.0	101.0	99.0	2.0
MEAN	98.3	94.7	3.7***	97.7	96.0	1.7***	99.7	97.0	2.7***
STD.DEV.	2.9	5.5	3.2	4.0	6.1	2.1	2.3	5.3	3.1
CRC E-15 Octane Requirement									
3	93.0	88.0	5.0	92.0	88.0	4.0	93.0	89.0	4.0
4	99.0	98.0	1.0	98.0	98.0	0.0	101.0**	101.0**	0.0
6	97.0	93.0	4.0	98.0	93.0	5.0	97.0	95.0	2.0
MEAN	96.3	93.0	3.3***	96.0	93.0	3.0***	97.0	95.0	2.0***
STD.DEV.	3.1	5.0	2.1	3.5	5.0	2.7	4.0	6.0	2.0

GROUP 8B

WEATHER-CORRECTED DATA

OBSV. NO.	FBRU LA	FBRU Denver	FBRU Diff.	FBRU 50% LA	FBRU 50% Denver	FBRU 50% Diff.	FBRSU LA	FBRSU Denver	FBRSU Diff.
Minimum Octane Requirement									
3	81.9	77.2	4.7	79.9	77.2	2.7	79.9	79.2	0.7
4	87.3	82.3	5.0	86.3	78.3	8.0	87.3	84.3	3.0
6	94.1	90.7	3.4	96.1	92.7	3.4	93.1	88.7	4.4
MEAN	87.8	83.4	4.4	87.4	82.7	4.7***	86.8	84.1	2.7***
STD.DEV.	6.1	6.8	0.8	8.2	8.6	2.9	6.6	4.8	1.9
Maximum Octane Requirement									
3	94.9	88.2	6.7	92.9	88.2	4.7	96.9	90.2	6.7
4	101.3	100.3	1.0	101.3	100.3	1.0	102.3	101.3	1.0
6	100.1	95.7	4.4	100.1	99.7	0.4	101.1	99.7	1.4
MEAN	98.8	94.7	4.0***	98.1	96.1	2.0***	100.1	97.1	3.0***
STD.DEV.	3.4	6.1	2.9	4.5	6.8	2.3	2.8	6.0	3.2
CRC E-15 Octane Requirement									
3	92.9	87.2	5.7	91.9	87.2	4.7	92.9	88.2	4.7
4	100.3	98.3	2.0	99.3	98.3	1.0	102.3	101.3	1.0
6	97.1	93.7	3.4	98.1	93.7	4.4	97.1	95.7	1.4
MEAN	96.8	93.1	3.7***	96.4	93.1	3.4***	97.4	95.1	2.4***
STD.DEV.	3.7	5.6	1.9	4.0	5.5	2.1	4.7	6.6	2.1

* Requirement below lowest reference fuel, 78 RON assigned.
** Requirement above highest reference fuel, 100 RON FBRU or 101 RON FBRSU assigned.
*** Not statistically significant at the 95% confidence level.
\+ 50th Percentile Acceleration Technique.